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# Effectiveness of group-based self-management education for individuals with Type 2 diabetes: a systematic review with meta-analyses and meta-regression

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**What's new?**

- We present a comprehensive up-to-date review of the evidence for the effectiveness of Type 2 diabetes group-based interventions. This is the first review in the area to complete a meta-regression.
- We report statistically significant results for improving $HbA_{1c}$, fasting blood glucose, body weight, waist circumference, triglycerides and diabetes knowledge, but clinical improvement is more nuanced.
- Group-based interventions facilitated by a single discipline, multidisciplinary teams or health professionals with peer supporters appear to be more effective at improving $HbA_{1c}$ than peer-led interventions.

## Abstract

**Aims** Patient education for the management of Type 2 diabetes can be delivered in various forms, with the goal of promoting and supporting positive self-management behaviours. This systematic review aimed to determine the effectiveness of group-based interventions compared with individual interventions or usual care for improving clinical, lifestyle and psychosocial outcomes in people with Type 2 diabetes.

**Methods** Six electronic databases were searched. Group-based education programmes for adults with Type 2 diabetes that measured $HbA_{1c}$ and followed participants for $\geq 6$ months were included. The primary outcome was $HbA_{1c}$, and secondary outcomes included fasting blood glucose, weight, BMI, waist circumference, blood pressure, blood lipid profiles, diabetes knowledge and self-efficacy.

**Results** Fifty-three publications describing 47 studies were included ($n$ = 8533 participants). Greater reductions in $HbA_{1c}$ occurred in group-based education compared with controls at 6–10 months [$n$ = 30 studies; mean difference (MD) = 3 mmol/mol (0.3%); 95% confidence interval (CI): –0.48, –0.15; $P$ = 0.0002], 12–14 months [$n$ = 27 studies; MD = 4 mmol/mol (0.3%); 95% CI: –0.49, –0.17; $P$ < 0.0001], 18 months [$n$ = 3 studies; MD = 8 mmol/mol (0.7%); 95% CI: –1.26, –0.18; $P$ = 0.009] and 36–48 months [$n$ = 5 studies; MD = 10 mmol/mol (0.9%); 95% CI: –1.52, –0.34; $P$ = 0.002], but not at 24 months. Outcomes also favoured group-based education for fasting blood glucose, body weight, waist circumference, triglyceride levels and diabetes knowledge, but not at all time points. Interventions facilitated by a single discipline, multidisciplinary teams or health professionals with peer supporters resulted in improved outcomes in $HbA_{1c}$ when compared with peer-led interventions.

**Conclusions** Group-based education interventions are more effective than usual care, waiting list control and individual education at improving clinical, lifestyle and psychosocial outcomes in people with Type 2 diabetes.

## Introduction

Patient education is an integral and vital component of successful diabetes care [1–3]. The main goal of diabetes patient education is to promote and support positive self-management behaviours to optimize metabolic control, improve long-term diabetes outcomes and quality of life (QOL), prevent complications, and reduce morbidity and mortality, while remaining cost-efficient [1,4]. Group-based education for individuals with Type 2 diabetes mellitus may be more cost-effective and efficient than individual education, due to the reduced time and funding required to educate numerous people in one sitting [5]. The potential advantages of

group-based education interventions over individual visits include time for the provision of more detailed information, decreased time demands on health workers, easily incorporating families and carers, and facilitating discussions and support from others facing the same challenges [6,7]. Clearly, the use of group-based education warrants further investigation.

Three previous systematic reviews included group education for Type 2 diabetes. A Cochrane systematic review assessed the effects of group-based training on clinical, lifestyle and psychosocial outcomes in people with Type 2 diabetes compared with routine treatment, waiting list control or no intervention [8]. The review favoured group-based education, finding significant improvements in $HbA_{1c}$ levels, body weight and systolic blood pressure (BP), fasting blood glucose (FBG), a decreased need for diabetes medication and increased diabetes knowledge [8]. A subsequent publication in 2012, updating the original Cochrane review, supported the findings of the former, favouring group-based education, with significant reductions in $HbA_{1c}$, FBG and body weight, and improvements in diabetes knowledge compared with controls [6]. Another recent systematic review [9] assessed the effect of diabetes self-management education and support methods, providers, duration and contact time on glycaemic control in adults diagnosed with Type 2 diabetes. The review included individual, group-based, combination and remote interventions for the management of Type 2 diabetes, with results suggesting that a combination of individual and group-based education was most effective at improving $HbA_{1c}$ (median 9.6 mmol/mol; 0.88%) when compared with controls [9].

These previous reviews had limitations. First, the searches are outdated and the number of published studies for group-based diabetes interventions has increased substantially since their completion. High heterogeneity precluded meta-analyses for several of the main outcomes, which were completed for just two studies [6,8]. Although both reviews found clinical and statistically significant changes in health outcomes, the exact mechanism or

'active ingredient(s)' of these complex interventions were not identified [6,8]. Both reviews only conducted follow-up analyses of the primary outcome up to 2 years from baseline [6,8]. The quality of the previous reviews was assessed using 'A Measurement Tool to Assess Systematic Reviews' (AMSTAR), a reliable and valid method for assessing the methodological quality of systematic reviews [10]. The AMSTAR scores were categorized in line with previous research [11,12], with scores of 0–4 classified as 'low quality', 5–8 classified as 'moderate quality', and 9–11 classified as 'high quality'. The Cochrane review [8] was assessed as a high-quality review (score: 9/11). This review lacked an assessment of publication bias and conflict of interest for the included studies. The review by Steinsbekk *et al.* [6] was assessed as a moderate quality review (score: 5/11); no protocol was available, grey literature and publication bias were not considered, a list of excluded studies was not provided, an assessment of conflict of interest for included studies was not explored and the scientific quality of the included studies was not used appropriately in formatting conclusions. The review by Chrvala *et al*. [9] was assessed as a moderate quality review (score: 7/11); grey literature and publication bias were not considered, a list of excluded studies was not provided and conflict of interest for included studies was not explored. The review had various limitations including: restricting included studies to English-language publications, including only randomized controlled trials, including interventions for individuals with either/both Type 1 and/or Type 2 diabetes, and an inability to conduct meta-analyses [9].

Despite these systematic reviews providing evidence of effectiveness, group-based education interventions are often complex and the characteristics of the interventions vary greatly, for example, in the number of contact hours, number of sessions, number and characteristics of participants, group facilitator(s) qualifications, facilitator training, theoretical framework, and whether family, friends or carers can attend [6,8]. Health professionals may deter from

group-based education because the essential attributes for a successful group-based education programme are unknown. Furthermore, no specific evidence-based practice guidelines for group-based education in Type 2 diabetes have been identified internationally, inevitably resulting in wide variations in the programmes offered, and creating difficulty in the interpretation of evidence and its translation to a practice setting.

This systematic review builds upon two of the previous reviews [6,8] and seeks to update the evidence for the effectiveness of group-based interventions for Type 2 diabetes management and investigate key attributes for successful group programs. It was hypothesized that:

- group-based interventions for Type 2 diabetes would have greater reductions in $HbA_{1c}$ compared with controls in the short (6 months) and long (> 12 months) term;
- group-based interventions for Type 2 diabetes would improve body weight, waist circumference, FBG, BP, lipid profiles, diabetes knowledge and self-efficacy, compared with controls;
- variations in effect sizes could be attributed to study design (i.e. setting, control group, educator), and intervention characteristics (i.e. number of participants, intervention length, number of contact hours).

## Methods

The study was registered with the International Prospective Register of Systematic Reviews PROSPERO (CRD42015027785).

**Data sources and search strategy**

A systematic literature search was performed to retrieve publications on group-based education for the management of Type 2 diabetes in adults. The search was completed in three parts. First, electronic databases, including PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), Embase, CINAHL, PsycINFO and ERIC, were searched from commencement of records to 22 September 2015 (File S1). Second, hand searches of reference lists from previous reviews were completed [6,8]. Finally, the included studies were cross-referenced with the results of an updated search by the authors of the most recent review including studies up to May 2012 (email correspondence). No language or date restrictions were applied. Abstract-only publications were excluded and duplicate articles were removed prior to title and abstract screening.

**Inclusion criteria and study selection**

Group-based education intervention studies for participants diagnosed with Type 2 diabetes that reported randomized controlled trials, cluster randomized trial or controlled clinical trial study designs were included. Studies were included if the described intervention met the following criteria: adults aged ≥ 18 years; face-to-face, educative group-based interventions (including those with occasional adjunct individual consultations) for people with Type 2 diabetes; a minimum of four participants and may include family and friends for support; a minimum of one session lasting for 1 h; groups delivered in primary or secondary care compared with a control or comparison group (usual care, waiting list control or individual intervention); and studies that measured $HbA_{1c}$ at both baseline and 6 or more months from baseline. Studies were excluded if participants were pregnant women or were diagnosed with

Type 1 diabetes, or interventions provided education in individual consultations, included only exercise prescriptions without education or were not conducted face-to-face.

All studies were screened against the eligibility criteria by two independent reviewers (KOJ and LEB) using reference manager software EndNote (Thomson Reuters, New York, NY, USA). Conflicts were resolved by discussion between them. Studies that met the inclusion criteria or did not include sufficient information for screening in the title and abstract, were included for full-text review. Full-text versions of these articles were obtained and screened independently. Authors were contacted for missing data up to three times by email if the missing data affected assessment of the study's eligibility, and were excluded if contact could not be made.

**Data extraction and quality assessment**

Data extraction was completed by the first author (KOJ) and confirmed for accuracy by an independent reviewer (JTK). Data extracted included: general information on the study design, trial characteristics, intervention details, participant characteristics, outcome measures, results and information for appraising the risk of bias. Study quality was assessed using the Cochrane risk of bias tool [13] by two independent reviewers (KOJ and LEB). Disagreements were resolved through discussion. Risk of bias was ranked as low, unclear or high depending on whether a study had any element of bias (e.g. selection, performance, detection, attrition, reporting and other bias).

**Data synthesis and analysis**

Descriptive data from the included studies were summarized. Data were meta-analysed if the same measurement was used across three or more studies at the same time point. The primary outcome measure was change in $HbA_{1c}$ in group-based education vs. control. The secondary outcome measures were changes in FBG, weight, BMI, waist circumference, BP, total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, diabetes knowledge and self-efficacy. Prior to the meta-analyses, studies reporting FBG or lipid profile measures in mg/dl were converted to mmol/l; those reporting weight in lb were converted to kg.

Summaries of effect estimates were calculated by meta-analysis using the DerSimonian and Laird random effects model in Review Manager (RevMan, v. 5.3) [14]. Continuous data using the same measures were analysed with a weighted mean difference in outcomes between the intervention and control groups, whereas continuous data collected using a variety of measures were assessed using the standard mean difference (SMD). Heterogeneity was assessed using the *I*-squared statistic and reported following the Cochrane Handbook [13].

Mean differences (MD) and 95% confidence intervals (CI) were calculated in RevMan and standard error was calculated in Microsoft® Excel using the 95% CIs for the meta-regression. Separate analyses for the effect of group-based interventions on $HbA_{1c}$ were performed for the following subgroups: control groups, delivery setting, insulin therapy, type of educator(s), training of educator(s), baseline $HbA_{1c}$ levels, theoretical model and intervention content, materials, length, number of sessions, contact time, number of participants and the inclusion/exclusion of family and/or friends.

Sensitivity analyses were conducted to explore the influence of study quality (overall risk of bias and reporting bias), on $HbA_{1c}$ outcomes (as measured closest to intervention completion) and heterogeneity. Reporting bias and selective outcome reporting were chosen for the sensitivity analysis because studies that did not report the pre-specified outcomes or failed to include the results for an expected outcome may be reporting only results supporting the studies' aims or hypotheses. We also examined potential influences on the primary outcome for studies that had differences in $HbA_{1c}$ at baseline, large (defined as > 10%) compared with small attrition (defined as < 10%), and studies published in non-English journals due to potential publication bias.

Subgroup analyses were also conducted to examine the effects of different educators (health professionals, health professionals with peer support, peer or lay-persons), disciplines (single discipline compared with multidiscipline) and studies that included participants taking (and not taking) insulin on the primary outcome $HbA_{1c}$.

In addition, a univariate meta-regression was completed to explore potential associations between the size of effect and varying study and intervention characteristics [15]. Variables were similar to those explored in the subgroup analyses. A meta-regression was performed using Stata statistical software [16].

## Results

### Study selection

The search identified 14 016 results, from which 9764 publications were screened against the selection criteria, leaving 298 studies for full-text review (Fig. 1). Forty-seven studies reported in 53 publications were included in the systematic review (references provided in File S2).

A total of 8533 participants were included in the 47 studies (intervention group $n = 4416$, control group $n = 4117$). The mean age of participants was 60 years. Men made up 44% of participants in the both the intervention (1917 of 4383) and control (1799 of 4086) groups. Three of the 47 included studies (6%) recruited only women. Known duration of diabetes was reported by 29 of the 47 studies (62%). Mean duration of diabetes was 8.9 years for participants in the intervention group, and 9.4 years in the control group. Mean $HbA_{1c}$ level at baseline was 67 mmol/mol (8.3%) for both groups and ranged between 39 and 111 mmol/mol (5.7%–12.3%) for the intervention group and between 40 and 115 mmol/mol (5.8%–12.7%) for the control group. In 38 (81%) studies, the mean $HbA_{1c}$ was > 53 mmol/mol (7%) for both the intervention and control groups.

**Study characteristics**

Study characteristics are detailed in Table S1. Of the 47 studies included, 40 reported the results of randomized controlled trials, four reported results of controlled clinical trials and three reported the results of cluster randomized controlled trials. Most of the studies were carried out in the USA (18; 38%), the UK (6; 13%) and Italy (5; 11%). Forty-two of the studies were published in English, two in Spanish [17,18], two in Italian [19,20] and one in Dutch [21]. The studies were published between 1988 and 2015, and the length of follow-up was 6–60 months from baseline. Intervention characteristics varied in materials provided, discipline(s) of group educators and theoretical model used, as summarized in Table S2. Studies were conducted predominantly in primary care settings (32; 68%), with 15 (32%) of the studies delivered in secondary or tertiary care settings, for example, hospital diabetes centres or tertiary hospitals. Four publications [22–25] reported on multiple arm studies.

**Study quality**

Most studies were classified as having a moderate (31) or high (12) risk of bias, with four studies classified as having a low risk of bias (Table S3). Of the six risk of bias items, allocation concealment (selection bias), blinding of participants and personnel (performance bias), and blinding of outcome assessment (detection bias) were the least consistently described or were generally poorly conducted in the included studies (Fig. S1).

**Overall effects of group-based interventions for $HbA_{1c}$**

A meta-analysis was conducted to assess the effect of group-based education compared with control for all 47 included studies ($n$ = 7055) using the measure of $HbA_{1c}$ at the time point closest to the completion of each group-based education intervention (Fig. 2). Overall, compared with control, group-based intervention was effective in reducing $HbA_{1c}$ by 4 mmol/mol (0.3%) (95% CI: –0.51, –0.17; $P < 0.0001$; $I^2 = 84\%$). Heterogeneity was statistically significant and potential reasons for this were explored with sensitivity analyses.

The results of the meta-analyses for $HbA_{1c}$ and secondary outcome measures at various time points are provided in Table 1.

Group-based interventions significantly reduced $HbA_{1c}$ post intervention at most time points compared with controls. $HbA_{1c}$ was significantly reduced at 6–10 months post baseline [$n$ = 30 studies; MD = 3 mmol/mol (0.3%); 95% CI: –0.48, –0.15; $P = 0.0002$; $I^2 = 65\%$], 12–14 months post baseline [$n$ = 27 studies; MD = 4 mmol/mol (0.3%); 95% CI: –0.49, –0.17; $P < 0.0001$; $I^2 = 64\%$], 18 months [$n$ = 3 studies; MD = 8 mmol/mol (0.7%); 95% CI: –1.26, –0.18; $P = 0.009$; $I^2 = 50\%$] and at 36–48 months [$n$ = 5 studies; MD = 10 mmol/mol (0.9%); 95% CI: –1.52, –0.34; $P = 0.002$; $I^2 = 93\%$]. By contrast, when eight studies comparing

group-based interventions with controls measured $HbA_{1c}$ at 24 months post baseline, there was no significant difference between the groups. This time point also had the highest heterogeneity ($I^2$ = 94%).

There was variation in effectiveness in reducing FBG when comparing group-based interventions with controls. Group-based education was significantly more effective at reducing FBG compared with controls at 12–14 months post baseline ($n$ = 8 studies; MD = 0.68 mmol/l; 95% CI: –1.25, –0.11; $P$ = 0.02; $I^2$ = 55%). However, this was not the case for FBG when measured at 6–10 or 24 months post baseline. All time points were assessed as having significant heterogeneity.

Group-based education was significantly more effective at reducing body weight compared with controls at both 6–10 months ($n$ = 17 studies; MD = 1.22 kg; 95% CI: –2.22, –0.23; $P$ = 0.02; $I^2$ = 62%) and 12–14 months ($n$ = 9 studies; MD = 1.43 kg; 95% CI: –2.09, –0.77; $P$ < 0.0001; $I^2$ = 0%). Despite the statistically significant improvements in body weight at two time points, group-based education was not effective at significantly reducing BMI. Group-based education was significantly more effective at reducing waist circumference at 6–10 months ($n$ = 5 studies; MD = 1.19 cm; 95% CI: –2.34, –0.05; $P$ = 0.04; $I^2$ = 58%). However, although waist circumference showed a trend for improvement with group-based education at 12–14 months, the difference between groups was not significant ($n$ = 3 studies; MD = 0.79 cm; 95% CI: –1.96, 0.38; $P$ = 0.19; $I^2$ = 38%).

Both systolic and diastolic BP were measured at five time points (6–10, 12–14 and 24 months post baseline). When pooled, changes in systolic and diastolic BP were not statistically different between groups for any of these intervals. In addition, there were no significant differences in total cholesterol between group-based interventions and controls at any time point.

There were no statistically significant differences in HDL-cholesterol between groups at any time point. Heterogeneity was significant at all time points. There were mixed results for LDL-cholesterol when measured at two time points, 6–10 and 12–14 months (Table 1). At 6–10 months, the meta-analysis resulted in no significant differences between groups for LDL-cholesterol ($n$ = 12 studies; MD = 0.03 mmol/l; 95% CI: –0.13, 0.07; $P$ = 0.59; $I^2$ = 49%). The studies assessing LDL-cholesterol at 12–14 months showed a significant decrease in LDL favouring the control group ($n$ = 5 studies; MD = 0.08 mmol/l; 95% CI: 0.01, 0.15; $P$ = 0.04; $I^2$ = 0%). Group-based education was significantly more effective at reducing triglycerides at 6–10 months ($n$ = 14 studies; MD = 0.13 mmol/l; 95% CI: –0.24, –0.01; $P$ = 0.03; $I^2$ = 4%) and 24 months ($n$ = 3 studies; MD = 0.32 mmol/l; 95% CI: –0.58, –0.06; $P$ = 0.01; $I^2$ = 8%). At 12–14 months, the difference between groups for triglycerides were not significant ($n$ = 11 studies; MD = 0.04; 95% CI: –0.22, 0.14; $P$ = 0.66; $I^2$ = 68%).

Diabetes knowledge was reported by 16 studies and measured using a range of validated questionnaires. Group-based education was significantly associated with improved diabetes knowledge at two time points: 6–10 months ($n$ = 7 studies; SMD = 0.61; 95% CI: 0.14, 1.08; $P$ = 0.01; $I^2$ = 83%) and 12–14 months ($n$ = 7 studies; SMD = 0.58; 95% CI: 0.08, 0.97; $P$ = 0.02; $I^2$ = 93%). Self-efficacy was reported by five studies at three time points (6, 12 and 24 months). Group-based education showed a trend to improved self-efficacy at 12 months post baseline ($n$ = 3 studies; SMD = 0.15; 95% CI: –0.02, 0.33; $P$ = 0.08; $I^2$ = 0%), however, these measures were not significant. In addition, QOL, depression, energy intake and physical activity levels were assessed (Table S4).

**Subgroup analyses**

Analyses were completed for 13 subgroups using $HbA_{1c}$ at the point closest to the end of each of the group-based education interventions as the outcome measure (Table 2).

The type of educator subgroup analysis resulted in a significant subgroup difference ($P = 0.002$), with peer- and/or lay-led group-based interventions having no significant influence on improving $HbA_{1c}$ ($P = 0.80$). Interventions facilitated by single disciplines ($P = 0.0003$), multidisciplinary teams ($P = 0.02$) or health professionals with peer supporters ($P = 0.01$) were effective at significantly improving $HbA_{1c}$ (Table 2 and Fig. S2). Types of educators were further analysed to individual disciplines included in the 'single discipline' group, finding that physician-, dietitian- and nurse-led group-based education interventions were effective ($P < 0.00001$) at improving $HbA_{1c}$ (Fig. S3). Heterogeneity for both subgroup analyses was significant ($I^2 = 79.1\%$ and 89.2%, respectively). In addition, subgroup analysis of studies with regards to insulin therapy resulted in a significant subgroup difference ($P < 0.00001$), with interventions that excluded participants on insulin therapy resulting in greater reductions in $HbA_{1c}$ (Fig. S4). Heterogeneity for both subgroup analyses was significant ($I^2 = 69\%$ and 88%, respectively).

**Sensitivity analyses**

Sensitivity analyses were performed to explore the influence of study quality and characteristics on post-baseline $HbA_{1c}$ outcomes (Table 3) and heterogeneity. Forest plots for sensitivity analyses are reported in Figs S5–S9.

There were no significant differences in $HbA_{1c}$ outcomes when study quality and attrition were explored; all subgroups showed statistically significant improvements in $HbA_{1c}$ ($P \leq 0.05$). However, subgroups of studies assessed as being at high risk of reporting bias

(Fig. S6), having baseline differences between groups (Fig. S7) and studies published in non-English journals (Fig. S9) did not show significant improvements in $HbA_{1c}$.

### Meta-regression

We used study variables and intervention characteristics including theoretical model, discipline(s) of educator(s), educator training, materials provided, delivery in primary care, both groups $HbA_{1c}$ < 7% at baseline, intervention length, contact time, number of participants, number of sessions, and the inclusion of family and friends in a meta-regression to explore potential associations between the size of effect and study and intervention characteristics on $HbA_{1c}$ at post intervention. None of these variables explained significant portions of heterogeneity among the studies (Table S5).

## Discussion

This study systematically evaluated the effectiveness of group-based education for the management of Type 2 diabetes in adults. Given the high prevalence of Type 2 diabetes and the need for effective intervention, a synthesis of the most up-to-date literature is required. A previous review included only studies published prior to January 2008 [6]. This study fills this important gap and attempted to expand our understanding of effective intervention components.

Meta-analyses of the primary outcome measure, $HbA_{1c}$, resulted in statistically significant improvements at 6–10, 12–14, 18 and 36–48 months, but unexpectedly, not at 24 months post intervention. The meta-analysis at this time point had the highest heterogeneity ($I^2$ = 94%). One study [26], in which contact with intervention participants decreased after 6 months,

favoured the control group and appeared to be an outlier, with a mean difference increase in $HbA_{1c}$ of 0.60% (95% CI: 0.52, 0.68). When this, and three other studies [18,20,27] assessed as high risk, were excluded from the meta-analysis, heterogeneity decreased substantially ($I^2 = 0\%$) and $HbA_{1c}$ lowered in favour of the intervention group [$n = 4$ studies; MD = 6 mmol/mol (0.6%); 95% CI: –0.86, –0.32; $P < 0.0001$] at the 24-month time point. Statistically significant reductions ranged from 3 mmol/mol (0.3%) at 6–10 months when pooled for 30 studies to 10 mmol/mol (0.9%) at 36–48 months when pooled for five studies. Although these reductions did not reach 11 mmol/mol (1%), suggested as the level necessary to achieve clinical importance [28,29], similar-sized reductions in $HbA_{1c}$ are known to mediate the risk of Type 2 diabetes complications [30].

Variability in outcomes was found for some secondary outcome measures, specifically FBG, body weight, waist circumference, triglyceride levels and diabetes knowledge. For example, FBG was improved statistically by mean reductions of 0.68 mmol/l at 12–14 months, but not at other time points. Previous research suggests that improving FBG in people with Type 2 diabetes can reduce the development or progression of microvascular complications and can improve QOL [31]. Ideally, FBG should be maintained < 7.2 mmol/l in individuals with Type 2 diabetes [32]. Although the data suggest statistical improvements, only two of the eight studies included in the meta-analysis of FBG at 12–14 months resulted in reductions of FBG to < 7.2 mmol/l, suggesting that the improvements in FBG may be less clinically important. This may indicate that group-based education programmes are not effective at improving various secondary outcome measures when compared with controls, or that further consideration of these measures is required.

Body weight and waist circumference were statistically improved by group-based interventions at time points closer to intervention completion, indicating that interventions were effective at improving these measures; however, maintenance of these improvements

requires further consideration. Weight control is recognized as a central strategy in diabetes care [31], however, the reductions in body weight (range 0.62–1.43 kg) and waist circumference (range 0.79–1.19 cm) in this review are unlikely to be clinically important. It has been demonstrated that a sustained weight loss (> 12 months) of 5 kg in people with Type 2 diabetes is associated with a reduction in $HbA_{1c}$ of 6–11 mmol/mol (0.5%–1%) [33]. Furthermore, for overweight or obese individuals with Type 2 diabetes, a weight loss of at least 5% seems necessary to improve blood glucose, lipid profiles and blood pressure [34]. However, it is unclear whether the participants in the included studies were overweight or obese, and a recent study found that intensive lifestyle interventions focusing on weight loss in adults with Type 2 diabetes did not reduce the rate of cardiovascular events despite significant weight loss [35]. Waist circumference is a commonly utilized measure of total body fat, a useful predictor of visceral fat [36], and can be a better predictor of cardiovascular risk [37] than BMI. It is likely that the reductions in weight were not great enough to influence BMI measures. These results are in line with previous systematic reviews, which found no statistically significant differences in BMI between groups [6,8].

Despite improvement in various blood lipid (excepting LDL-cholesterol) and BP measures, statistical significance was not reached at most time points. There may be several reasons for this: the limited number of studies assessing or providing education on these measures, the lack of intervention focus on blood lipids or BP, the widespread and early use of pharmacological interventions, the inclusion of participants on cholesterol-reducing or hypotensive medications, and underpowered studies to detect changes in blood lipids or BP. The results highlight an important area for future research, given that improvements in lipid measures and BP control in Type 2 diabetes can reduce the risk of death related to diabetes, macrovascular and microvascular complications and myocardial infarction [29].

The meta-analyses indicate that group-based interventions are effective at improving diabetes knowledge, but no differences in self-efficacy were evident. Perceived self-efficacy describes a person's confidence or belief about his or her personal capabilities to accomplish a task or change a behaviour [38]. The found improvement in diabetes knowledge is consistent with two previous systematic reviews [6,8]. Successful self-management of Type 2 diabetes requires sufficient knowledge of the condition and its treatment, and the performance of self-management activities and skills [39], and knowledge is an essential prerequisite [1].

The subgroup analyses revealed that peer- or lay-led group-based interventions did not significantly reduce $HbA_{1c}$; however, interventions facilitated by single disciplines, multidisciplinary teams or health professionals with peer supporters resulted in statistical improvements in $HbA_{1c}$. Furthermore, subgroup analysis of single educator studies indicated that physician-, dietitian- and nurse-led group-based education interventions were equally effective at improving $HbA_{1c}$ levels. The International Diabetes Federation guideline recommends that an appropriately trained multidisciplinary team provides education to groups of people with diabetes [40]. It defines limited care as group education by a smaller team, for example, with a physician and diabetes educator or, in very limited situations, an appropriately skilled individual [40]. By contrast, and similar to the previous review [6], the results of this review indicate that educators from a single discipline providing group-based education to persons with Type 2 diabetes can be more effective than multidisciplinary teams. Multidisciplinary teams may result in reduced contact time with each educator, thus limiting the participant's development of relationships and level of perceived support. Support from group educators can enhance the development of self-management skills in people with Type 2 diabetes [41–43], with researchers suggesting that this support can influence an individual's motivation to self-manage their condition [44,45].

Our results support the use of peer facilitators complementing health professionals, rather than replacing them [7]. Peer support can enhance and complement other healthcare services, can provide role-modelling and practical, emotional and ongoing support, and can assist individuals to follow management plans, cope with the stressors of chronic disease and remain motivated [46,47]. The benefits of peer support include the establishment of a non-hierarchical, reciprocal relationship with the individual, and the ability to share knowledge, life experience and common illness experiences, which many health workers would not have [7].

Although $HbA_{1c}$ did improve statistically in both groups as expected, studies that excluded participants that used insulin showed greater improvements in $HbA_{1c}$ than studies that included them. This was an expected result, because insulin therapy lowers blood glucose and $HbA_{1c}$, resulting in tighter glycaemic control [32].

Despite the lack of statistically significant differences between subgroups, some subgroup analyses resulted in significant improvements, whereas others did not. To improve $HbA_{1c}$ outcomes for individuals with Type 2 diabetes, the following characteristics of group-based interventions may be associated with greater effects: conducted in primary care settings; provide materials to participants; have < 10 sessions provided either in < 1 month, or over 7–12 or 13–60 months; provide < 8, 8–12, 19–30 or 31 h or more of contact time; include < 20 participants in each group; and include individuals with $HbA_{1c}$ levels > 53 mmol/mol (7%). Although not directly comparable because we did not reach a pooled reduction of $HbA_{1c}$ of 11 mmol/mol (1%), these results differed from the findings from a previous systematic review which found that the only predictor of a reduction in $HbA_{1c}$ of 11 mmol/mol (1%) was contact time of 23.6 h [4]. Furthermore, a previous systematic review found that group-based interventions delivered in < 10 months, with > 12 h of contact time over 6–10 sessions were

most efficacious in improving $HbA_{1c}$ [6]. The reasons for the different results relative to the contact time are likely due to other intervention factors, such as intervention content, facilitators or intervention length.

Finally, studies in which the content was facilitator-directed resulted in significant improvements in $HbA_{1c}$, whereas patient-directed interventions did not. These results contradict the findings from previous studies, which support the use of a patient-centred approach, suggesting that engaging individuals in their healthcare decisions can enhance their adherence to therapy [32]. Patient-directed interventions, in which participants decide on the content covered in the intervention and can therefore explore their own agenda, interests and needs, have been suggested to be effective in improving participant knowledge, blood glucose levels, weight and medication usage, as well as assisting the development of self-management behaviours [48,49]. Facilitator-directed programmes contain lesson plans with clearly defined content selected by intervention facilitators. This allows programmes to be replicated by multiple facilitators; however, they may be more likely to utilize a didactic facilitation style, which could reduce time for group interactions and discussion [48]. The subgroup analysis in the current study, however, was underpowered, with only four studies utilizing a patient-centred approach, compared with 43 studies utilizing a facilitator-directed approach. Furthermore, studies that compared group-based interventions to usual care were effective at improving $HbA_{1c}$, whereas those compared with other comparators (e.g. individual education, waiting list control), did not significantly improve $HbA_{1c}$. However, this analysis did not result in a significant difference between groups, and was underpowered, with 28 (65%) of the studies comparing to usual care controls.

**Limitations**

Although our study has many strengths, there are several limitations. Using the AMSTAR quality assessment tool, our review is of high quality (10/11). A search of the grey literature in the area was not completed and may have resulted in publication bias. However, we conducted sensitivity analysis to consider the influence of publication bias when studies were published in non-English journals and found no differences in the primary outcome. Most studies included in the review were assessed as having a moderate (31 of 47 studies) or high (12 of 47 studies) risk of bias. As such, the results should be interpreted with caution. Thirteen studies were assessed as having a potential conflict of interest either due to partial funding or equipment donations by pharmaceutical companies, or possible financial gains to the authors from commercially available materials and training courses (Table S1). Only 5 of the 47 included studies measured hypoglycaemia, an important end point, unwanted consequence of therapy and commonly feared acute complication in Type 2 diabetes [31]. Furthermore, the authors were unable to explore the barriers and enablers regarding the implementation of education programmes because this information was not commonly provided in published reports.

Numerous meta-analyses resulted in high heterogeneity between studies; however, this is common in allied health research, particularly in complex interventions, and was assessed comprehensively through sensitivity analyses, subgroup analyses and a univariate meta-regression. Furthermore, the two previous systematic reviews also had high heterogeneity, with the Cochrane review reporting $I^2$ scores between 0% and 96.4% [8] and a review by Steinsbekk *et al.* [6] reporting $I^2$ scores between 0% and 85.5%.

## Conclusions

The 47 studies included in this systematic review provide evidence supporting the use of group-based education for the management of Type 2 diabetes to significantly improve $HbA_{1c}$, FBG, body weight, waist circumference, triglycerides and diabetes knowledge. However, the results may not be clinically important and were complex, with most outcomes improving at time points proximal to the intervention, but others improving at more distal time points. In addition, the results should be interpreted with caution due to the high heterogeneity of some of the meta-analyses, as well as assessment of most of the included studies as having a moderate or high risk of bias. Group-based education interventions facilitated by single disciplines, multidisciplinary teams or health professionals with peer supporters result in improved outcomes in $HbA_{1c}$ when compared with peer-led interventions. The lack of statistical significance in all but two of the subgroup analyses may indicate that other factors such as peer identification, normalization and group interactions are the 'active ingredient(s)' and, as such, substantially influence the effectiveness of group-based education interventions for the management of Type 2 diabetes. Future research should explore these factors, as well as the cost-effectiveness of, and barriers and facilitators to implementing group-based education programmes for the management of Type 2 diabetes. Finally, future interventions should consider hypoglycaemia as an important end point.

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**Competing interests**

None declared.

**Author contributions**

KOJ undertook this project as part of her PhD and had a principal role in study conception and design, screening, data extraction, risk of bias, data analysis and interpretation, and wrote the first draft of the manuscript. LEB assisted with the study conception and design, screening and risk of bias. JTK assisted with screening, data extraction, and data analysis. RT assisted with the study conception and design, data analysis and interpretation. EAI and DPR assisted with the study conception and design. All six authors commented critically on the manuscript and approved it for submission.

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**FIGURE 1** Stages of study identification

**FIGURE 2** Effectiveness of group-based interventions compared with controls for Type 2 diabetes for $HbA_{1c}$ (%). Risk of bias: A, random sequence generation (selection bias); B, allocation concealment (selection bias); C, blinding of participants and personnel (performance bias); D, blinding of outcome assessment (detection bias); E, incomplete outcome data (attrition bias); F, selective reporting (reporting bias); G, other bias.

## Supporting Information

Additional Supporting Information may be found in the online version of this article:

**Figure S1** Overall risk of bias for the included studies.

**Figure S2** Forest plot – subgroup analysis of group educators.

**Figure S3** Forest plot – subgroup analysis of group educators by individual discipline.

**Figure S4** Forest plot – subgroup analysis of insulin therapy.

**Figure S5** Forest plot – sensitivity analysis: overall risk of bias.

**Figure S6** Forest plot – sensitivity analysis: reporting bias.

**Figure S7** Forest plot – sensitivity analysis: baseline differences.

**Figure S8** Forest plot – sensitivity analysis: attrition.

**Figure S9** Forest plot – sensitivity analysis: published in non-English journals.

**Table S1** Characteristics of the included studies.

**Table S2** Intervention characteristics of the included studies.

**Table S3** Risk of bias summary of studies included in the systematic review.

**Table S4** Summary of meta-analysis results of secondary outcomes assessed using standard mean difference at various time points.

**Table S5** Meta-regression: association between study variables and primary outcome measure ($HbA_{1c}$).

**File S1** Search strategy for PubMed.

**File S2** References for included studies.

**Table 1** Summary of meta-analysis results for primary and secondary outcome measures at various time points

| Outcome | Time point (months) | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | *P*-value | Heterogeneity (%) ($I^2$) | Heterogeneity (*P*-value) |
|---|---|---|---|---|---|---|---|
| $HbA_{1c}$ (%) | 6–10 | 30 | 2155/1952 | –0.31 (–0.48, –0.15) | 0.0002 | 65 | < 0.00001 |
| | 12–14 | 27 | 2233/2151 | –0.33 (–0.49, –0.17) | < 0.0001 | 64 | < 0.00001 |
| | 18 | 3 | 98/96 | –0.72 (–1.26, –0.18) | 0.009 | 50 | 0.13 |
| | 24 | 8 | 551/555 | –0.33 (–0.82, 0.17) | 0.20 | 94 | < 0.00001 |
| | 36–48 | 5 | 747/689 | –0.93 (–1.52, –0.34) | 0.002 | 93 | < 0.00001 |
| Fasting blood glucose (mmol/l) | 6–10 | 10 | 454/461 | –0.24 (–0.95, 0.47) | 0.51 | 79 | < 0.00001 |

| Outcome | Time point (months) | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | *P*-value | Heterogeneity (%) ($I^2$) | Heterogeneity (*P*-value) |
|---|---|---|---|---|---|---|---|
| | 12–14 | 8 | 496/575 | –0.68 (–1.25, –0.11) | 0.02 | 55 | 0.03 |
| | 24 | 4 | 204/209 | –0.10 (–1.60, 1.39) | 0.89 | 88 | < 0.0001 |
| Weight (kg) | 6–10 | 17 | 1341/1172 | –1.22 (–2.22, –0.23) | 0.02 | 62 | 0.0003 |
| | 12–14 | 9 | 804/760 | –1.43 (–2.09, –0.77) | < 0.0001 | 0 | 0.88 |
| | 36–48 | 4 | 714/605 | –0.62 (–1.69, 0.45) | 0.25 | 0 | 0.77 |
| BMI ($kg/m^2$) | 6–10 | 18 | 1019/1016 | –0.00 (–0.44, 0.44) | 0.99 | 36 | 0.07 |
| | 12–14 | 13 | 962/1082 | 0.19 (–0.37, 0.75) | 0.51 | 55 | 0.009 |
| | 24 | 6 | 496/502 | 0.80 (–0.93, 2.54) | 0.36 | 89 | < 0.00001 |
| Waist circumference (cm) | 6–10 | 5 | 520/466 | –1.19 (–2.34, –0.05) | 0.04 | 58 | 0.05 |
| | 12–14 | 3 | 579/509 | –0.79 (–1.96, 0.38) | 0.19 | 38 | 0.20 |
| Systolic blood pressure (mmHg) | 6–10 | 17 | 1359/1218 | 0.12 (–1.44, 1.67) | 0.88 | 38 | 0.05 |
| | 12–14 | 11 | 1087/1083 | –0.49 (–1.90, 0.92) | 0.49 | 0 | 0.45 |
| | 24 | 4 | 263/265 | –0.68 (–5.43, 4.07) | 0.78 | 40 | 0.17 |
| | 36–48 | 4 | 714/605 | –1.71 (–5.76, 2.34) | 0.41 | 66 | 0.03 |
| Diastolic blood pressure (mmHg) | 6–10 | 17 | 1435/1261 | –1.77 (–3.73, 0.20) | 0.08 | 92 | < 0.00001 |
| | 12–14 | 11 | 1087/1083 | –0.80 (–1.71, 0.12) | 0.09 | 0 | 0.46 |

| Outcome | Time point (months) | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | *P*-value | Heterogeneity (%) ($I^2$) | Heterogeneity (*P*-value) |
|---|---|---|---|---|---|---|---|
| | 24 | 3 | 97/94 | 1.12 (–1.77, 4) | 0.45 | 17 | 0.30 |
| | 36–48 | 4 | 714/605 | –1.13 (–2.70, 0.43) | 0.16 | 40 | 0.17 |
| Total cholesterol (mmol/l) | 6–10 | 15 | 1153/1117 | –0.01 (–0.16, 0.14) | 0.87 | 75 | < 0.00001 |
| | 12–14 | 9 | 891/928 | 0.01 (–0.12, 0.15) | 0.84 | 44 | 0.07 |
| | 24 | 3 | 241/243 | –0.10 (–0.56, 0.36) | 0.67 | 81 | 0.005 |
| | 36–48 | 3 | 692/583 | –0.23 (–0.65, 0.18) | 0.27 | 88 | 0.0003 |
| HDL cholesterol (mmol/l) | 6–10 | 13 | 967/906 | 0.16 (–0.09, 0.41) | 0.22 | 99 | < 0.00001 |
| | 12–14 | 10 | 915/943 | 0.02 (–0.02, 0.07) | 0.28 | 74 | < 0.0001 |
| | 36–48 | 3 | 692/583 | 0.04 (–0.10, 0.18) | 0.59 | 94 | < 0.00001 |
| LDL cholesterol (mmol/l) | 6–10 | 12 | 571/560 | –0.03 (–0.13, 0.07) | 0.59 | 49 | 0.03 |
| | 12–14 | 5 | 333/398 | 0.08 (0.01, 0.15) | 0.04 | 0 | 0.44 |
| Triglycerides (mmol/l) | 6–10 | 14 | 1105/1045 | –0.13 (–0.24, –0.01) | 0.03 | 4 | 0.41 |
| | 12–14 | 11 | 1045/1069 | –0.04 (–0.22, 0.14) | 0.66 | 68 | 0.0005 |
| | 24 | 3 | 118/119 | –0.32 (–0.58, –0.06) | 0.01 | 8 | 0.34 |

| Outcome | Time point (months) | No. studies | No. participants (IG/CG) | Standard mean difference (95% CI) | *P*-value | Heterogeneity (%) ($I^2$) | Heterogeneity (*P*-value) |
|---|---|---|---|---|---|---|---|
| Diabetes knowledge | 6–10 | 7 | 239/240 | 0.61 (0.14, 1.08) | 0.01 | 83 | < 0.00001 |

| Outcome | Time point (months) | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | *P*-value | Heterogeneity (%) ($I^2$) | Heterogeneity (*P*-value) |
|---|---|---|---|---|---|---|---|
| | 12–14 | 7 | 609/682 | 0.58 (0.08, 0.97) | 0.02 | 93 | < 0.00001 |
| Self-efficacy | 12 | 3 | 256/272 | 0.15 (–0.02, 0.33) | 0.08 | 0 | 0.92 |

IG, intervention group; CG, control group; CI, confidence interval.

**Table 2** Subgroup analysis results for primary outcome measure ($HbA_{1c}$; %)

| Analysis outcome | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | Overall effect: *P*-value | Heterogeneity (%) | Subgroup differences: *P*-value |
|---|---|---|---|---|---|---|
| Control group | 47 | 3579/3476 | – | – | – | 0.60 |
| Usual care | 28 | 2414/2322 | –0.42 (–0.66, –0.18) | 0.0007 | 88 | |
| Waiting list control | 4 | 243/251 | –0.34 (–0.85, 0.18) | 0.20 | 70 | |
| Individual intervention | 6 | 542/532 | –0.05 (–0.50, 0.40) | 0.82 | 81 | |
| Usual care with written materials | 6 | 315/412 | –0.21 (–0.54, 0.12) | 0.21 | 61 | |
| Group education prior to usual care | 3 | 65/63 | –0.48 (–1.03, 0.07) | 0.09 | 34 | |
| Delivery setting | 47 | 3579/3476 | – | – | – | 0.38 |
| Primary care | 34 | 2858/2808 | –0.28 (–0.41, –0.16) | < 0.0001 | 59 | |
| Other | 13 | 721/668 | –0.52 (–1.02, –0.01) | 0.05 | 93 | |
| Type of educators | 47 | 3579/3476 | – | – | – | 0.002 |
| Peer or lay led | 5 | 530/536 | 0.02 (–0.12, 0.16) | 0.80 | 0 | |
| Health professional led with peer support | 5 | 517/502 | –0.27 (–0.48, –0.06) | 0.01 | 0 | |
| Single discipline | 17 | 1054/1080 | –0.56 (–0.86, –0.26) | 0.0003 | 86 | |
| Multidisciplinary | 20 | 1478/1358 | –0.24 (–0.43, –0.04) | 0.02 | 61 | |
| Training: | 47 | 3579/3476 | – | – | – | 0.82 |
| Yes | 34 | 2915/2814 | –0.33 (–0.53, –0.13) | 0.001 | 87 | |
| No | 13 | 664/662 | –0.38 (–0.70, –0.05) | 0.02 | 69 | |
| Baseline $HbA_{1c}$ levels | 47 | 3579/3476 | – | – | – | 0.52 |
| > 7 in both groups | 38 | 3043/2937 | –0.37 (–0.56, –0.17) | 0.002 | 85 | |
| < 7 in both groups | 9 | 536/539 | –0.24 (–0.60, 0.13) | 0.21 | 82 | |
| Insulin therapy | 38 | 2978/2893 | – | – | – | < 0.0001 |
| Yes | 20 | 1809/1661 | –0.19 (–0.28, –0.10) | < 0.0001 | 69 | |
| No | 18 | 1169/1232 | –0.81 (–0.92, –0.70) | < 0.00001 | 88 | |
| Theoretical model | 47 | 3579/3476 | – | – | – | 0.48 |
| Yes | 24 | 2227/2089 | –0.39 (–0.65, –0.12) | 0.004 | 89 | |
| No | 23 | 1352/1387 | –0.27 (–0.46, –0.09) | 0.003 | 62 | |
| Intervention content | 47 | 3579/3476 | – | – | – | 0.75 |
| Facilitator–directed | 43 | 3306/3226 | –0.34 (–0.52, –0.15) | 0.0003 | 85 | |
| Patient–directed | 4 | 273/250 | –0.42 (–0.94, 0.09) | 0.11 | 73 | |
| Materials | 47 | 3579/3476 | – | – | – | 0.90 |
| Yes | 40 | 3182/3100 | –0.34 (–0.53, –0.15) | 0.0004 | 85 | |
| No | 7 | 397/376 | –0.37 (–0.83, 0.09) | 0.12 | 84 | |

| Analysis outcome | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | Overall effect: *P*-value | Heterogeneity (%) | Subgroup differences: *P*-value |
|---|---|---|---|---|---|---|
| Intervention length (months) | 47 | 3579/3476 | – | – | – | 0.53 |
| < 1 | 6 | 875/790 | –0.33 (–0.64, –0.02) | 0.04 | 56 | |
| 1–3 | 8 | 585/546 | –0.20 (–0.50, 0.10) | 0.19 | 71 | |
| 4–6 | 11 | 501/486 | –0.19 (–0.48, 0.10) | 0.20 | 67 | |
| 7–12 | 13 | 824/850 | –0.32 (–0.55, –0.09) | 0.007 | 54 | |
| 13–60 | 9 | 794/804 | –0.66 (–1.14, –0.18) | 0.007 | 93 | |
| Number of sessions | 47 | 3579/3476 | – | – | – | 0.34 |
| < 5 | 13 | 1223/1208 | –0.46 (–0.70, –0.23) | < 0.0001 | 68 | |
| 6–10 | 21 | 1360/1294 | –0.20 (–0.39, –0.01) | 0.04 | 71 | |
| 11–20 | 8 | 707/678 | –0.48 (–1.04, 0.09) | 0.10 | 92 | |
| > 21 | 5 | 289/296 | –0.31 (–0.71, 0.09) | 0.13 | 41 | |
| Contact time (h) | 47 | 3579/3476 | – | – | – | 0.72 |
| ≤ 8 | 13 | 1168/1033 | –0.45 (–0.74, –0.17) | 0.002 | 72 | |
| 9–12 | 7 | 536/557 | –0.35 (–0.59, –0.11) | 0.004 | 55 | |
| 13–18 | 10 | 909/909 | –0.19 (–0.74, 0.35) | 0.48 | 96 | |
| 19–30 | 9 | 348/352 | –0.42 (–0.77, –0.08) | 0.02 | 58 | |
| ≥ 31 | 8 | 618/625 | –0.25 (–0.42, –0.09) | 0.003 | 0 | |
| Number of participants | 47 | 3579/3476 | – | – | – | 0.40 |
| 4–10 | 32 | 2563/2426 | –0.39 (–0.16, –0.17) | 0.0006 | 87 | |
| 11–20 | 15 | 1016/1050 | –0.25 (–0.48, –0.02) | 0.03 | 64 | |
| Family and friends | 47 | 3579/3476 | – | – | – | 0.70 |
| Yes | 29 | 2841/2700 | –0.36 (–0.59, –0.13) | 0.002 | 88 | |
| No | 18 | 738/776 | –0.30 (–0.52, –0.08) | 0.008 | 67 | |

IG, intervention group; CG, control group; CI, confidence interval.

**Table 3** Sensitivity analysis results for primary outcome measure ($HbA_{1c}$; %)

| Analysis outcome | No. studies | No. participants (IG/CG) | Mean difference (95% CI) | *P*-value | Heterogeneity (%) | Subgroup differences: *P*-value |
|---|---|---|---|---|---|---|
| Overall risk of bias | 47 | 3579/3476 | – | – | – | 0.92 |
| Low | 4 | 409/375 | –0.40 (–0.75, –0.06) | 0.02 | 52 | |
| Moderate | 31 | 2011/1963 | –0.35 (–0.59, –0.12) | 0.003 | 88 | |
| High | 12 | 1159/1138 | –0.31 (–0.59, –0.02) | 0.03 | 74 | |
| Reporting bias | 47 | 3579/3476 | – | – | – | 0.38 |
| Low | 38 | 2792/2734 | –0.38 (–0.58, –0.18) | 0.0002 | 86 | |
| High | 9 | 787/742 | –0.22 (–0.52, 0.08) | 0.16 | 69 | |
| Baseline differences | 47 | 3579/3476 | – | – | – | 0.68 |
| Yes | 10 | 737/695 | –0.27 (–0.62, 0.07) | 0.12 | 70 | |
| No | 37 | 2842/2781 | –0.36 (–0.55, –0.16) | 0.0004 | 86 | |
| Dropout | 47 | 3579/3476 | – | – | – | 0.09 |
| < 10% attrition | 14 | 1043/949 | –0.53 (–0.72, –0.34) | < 0.00001 | 41 | |
| > 10% attrition | 33 | 2536/2527 | –0.27 (–0.49, –0.05) | 0.02 | 88 | |
| Translated publication | 47 | 3579/3476 | – | – | – | 0.48 |
| Yes | 42 | 3313/3206 | –0.36 (–0.55, –0.18) | < 0.0001 | 85 | |
| No | 5 | 409/375 | –0.15 (–0.72, 0.42) | 0.61 | 74 | |

IG, intervention group; CG, control group; CI, confidence interval.

***Figure 1: Stages of Study Identification***

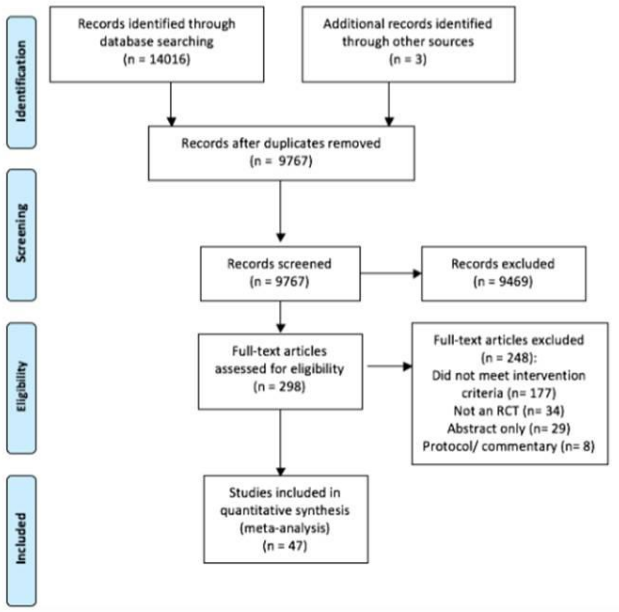
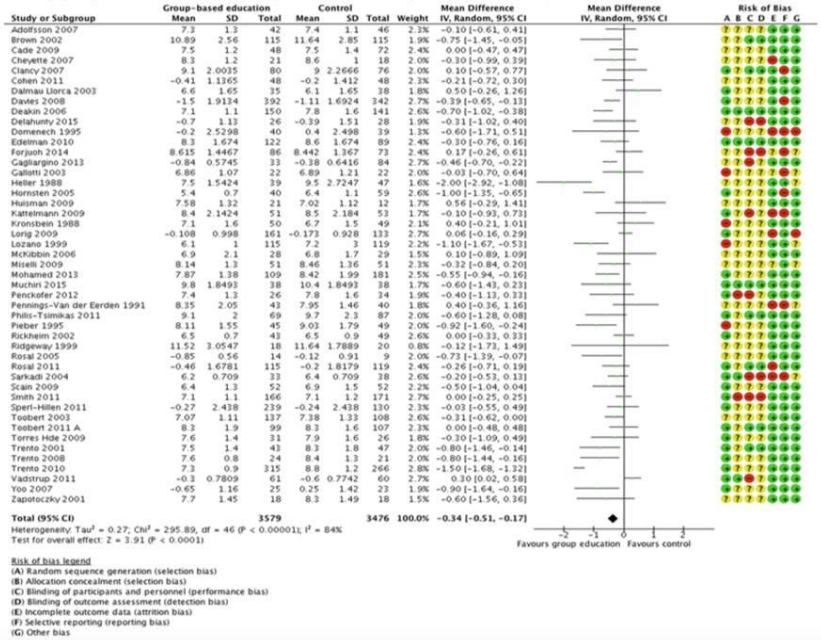



***Figure 2: Effectiveness of group-based interventions compared with controls for Type 2 diabetes for HbA1c[%]***



# Supplemental Data

***Supplemental Item S1: Search Strategy for PubMed***

We used the following search strategy to search Pubmed. The search strategy was adapted to search the Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, CINAHL, PsycINFO, and ERIC. There were no language or date restrictions.

**Pubmed**

"Patient Education as Topic"[Mesh] OR "Self Care"[Mesh] OR "Behavior Therapy"[Mesh] OR "Group Processes"[Mesh] OR "Psychotherapy, Group"[Mesh] OR "Self-Help Groups"[Mesh] OR Patient education[tiab] or Self care[tiab] OR Self-care[tiab] OR Self management[tiab] OR Self-management[tiab] OR Behavior therapy[tiab] OR Behaviour therapy[tiab] OR Group process[tiab] OR Group processes[tiab] OR Group psychotherapy[tiab]

AND

"Diabetes Mellitus, Type 2"[Mesh] OR MODY[tiab] OR NIDDM[tiab] OR T2DM[tiab] OR ((non insulin[tiab] OR noninsulin[tiab] OR “Type 2”[tiab] OR “Type II”[tiab] OR Ketosis-Resistant[tiab] OR Ketosis resistant[tiab] OR Maturity-Onset[tiab] OR Maturity onset[tiab] OR Mature-onset[tiab] OR Mature onset[tiab] OR Adult-onset[tiab] OR Adult onset[tiab] OR Slow-onset[tiab] OR Slow onset[tiab] OR Stable[tiab]) AND Diabetes)

AND

Group[tiab] OR Groups[tiab]

NOT

"Diabetes Insipidus"[Mesh] OR Diabetes Insipidus[tiab]

AND

randomized controlled trial[Publication Type] OR controlled clinical trial[Publication Type] OR randomized[Title/Abstract] OR randomised[Title/Abstract] OR placebo[Title/Abstract] OR "drug therapy"[MeSH Terms] OR randomly[Title/Abstract] OR trial[Title/Abstract] OR groups[Title/Abstract]

***Supplemental Table S1: Study characteristics of included studies****

| Author, Year, Country | Study design | Length of follow up in months | Setting | No. at recruitment | No. at follow up | Mean baseline age (SD) | Gender: % Male | Mean baseline HbA1c | Conflict of interest |
|---|---|---|---|---|---|---|---|---|---|
| Adolfsson 2007, Sweden[1] | RCT | 12 | Primary care | IG: 42; CG: 46 | IG: 42; CG: 46 | IG: 62.4 (8.9); CG: 63.7 (9.0) | IG: 57%; CG: 61% | IG: 7.4; CG: 7.1 | No |
| Brown 2002, USA[2] | RCT | 12 | Primary care | IG: 128; CG: 128 | IG: 115; CG: 115 | IG: 54.7 (8.2), CG: 53.3 (8.3) | IG: 40%; CG: 32% | IG: 11.8; CG: 11.8 | No |
| Cade 2009, UK[3] | RCT | 12 | Primary care | IG: 122; CG: 127 | IG: 86; CG: 108 | IG: 65.8 (11), CG: 66.6 (11) | IG: 62%; CG: 58% | IG: 7.3; CG: 7.5 | No |
| Cheyette 2007, UK[4] | RCT | 12 | Secondary care | IG: 29; CG: 20 | IG: 21; CG: 18 | IG: 56.7 (9.7); CG: 58 (10.7) | IG: 48%; CG: 60% | IG: 8.2; CG: 8.2 | No |
| Clancy 2007, USA[5] | RCT | 12 | Primary care | IG: 96; CG: 90 | IG: 80; CG: 76 | IG: 55; CG: 57 | IG: 26%; CG: 30% | IG: 9.3; CG: 8.9 | Yes |
| Cohen 2011, USA[6] | RCT | 6 | Primary care | IG: 50; CG: 49 | IG: 48; CG: 48 | IG: 69.8 (10.7); CG: 67.2 (9.4) | IG: 100%; CG: 96% | IG: 7.8; CG: 8.1 | No |
| Dalmau Llorca 2003, Spain[7] | RCT | 12 | Primary care | IG: 33; CG: 35 | IG: 35; CG: 38 | IG: 64.9 (8.2); CG: 65.6 (8.1) | IG: 64.7%, CG: 35.3% | IG: 7.2; CG: 6.6 | Unclear |
| Davies 2008[8]/ Khunti 2012, UK[9] | Cluster RCT | 12/ 36 | Primary care | IG: 437; CG: 387 | IG: 404; CG: 345/ IG: 332; CG: 272 | IG: 59.4 (11.6), CG: 61.01 (12.1) | IG: 53%; CG: 57% | IG: 8.3; CG: 7.9 | No |
| Deakin 2006, UK[10] | RCT | 14 | Primary care | IG: 157; CG: 157 | IG: 150; CG: 141 | IG: 61.3 (9.7); CG: 61.8 (11) | IG: 52% CG: 52% | IG: 7.7; CG: 7.7 | Yes |
| Delahanty 2015, USA[11] | RCT | 6 | Primary care | IG: 28, CG: 29 | IG: 26; CG: 28 | IG: 62 (9.6), CG: 61 (11.4) | IG: 61%; CG: 59% | IG: 8.1; CG: 8.3 | No |
| Domenech 1995, Argentina[12] | CCT | 12 | Primary care | IG: 40; CG: 39 | IG: 40; CG: 39 | IG: 52.7 (3.1); CG: 53.1 (1.1) | IG: 55%; CG: 56% | IG: 9; CG: 9 | Yes |
| Edelman 2010, USA[13] | RCT | 12.8 | Primary care | IG: 133; CG: 106 | IG: 122; CG: 89 | IG: 63 (9.4); CG: 60.8 (10) | IG: 95.5%; CG: 96.2% | IG: 9.2; CG: 9.2 | Unclear |
| Forjuoh 2014, USA[14] | RCT | 12 | Primary care | IG: 101; CG: 95 | IG: 86; CG: 73 | IG: 57.6 (10.9) CG: 57.6 (10.9) | IG 46.5%, CG 44.2% | IG: 9.2; CG: 9.0 | Unclear |
| Gagliardino 2013, Argentina[15] | RCT | 42 | Primary care | G1: 117; G3: 117; G4: 117 | G1: 84; G3: 86; G4: 33 | G1 62 (8.4); G3 62.2 (8.4); G4 62.2 (8.4) | G1 32.5%, G3 33.3%, G4 37.6% | IG: 7.7; CG: 7.8 | No |
| Gallotti 2003, Italy[16] | CCT | 36 | Primary care | IG: 22; CG: 22 | IG: 22; CG: 22 | IG & CG: 56-73 yrs | IG: 55%; CG: 55% | IG: 6.9; CG: 6.8 | Unclear |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Heller 1988, UK[17] | RCT | 12 | Secondary care | IG: 36; CG: 39 | IG: 35; CG: 39 | IG 56.5 (55-58); CG 56.4 (53-59.9) | IG 55%, CG 41% | IG: 12.3; CG: 12.7 | Yes |
| Hornsten 2005& 2008, Sweden[18, 19] | Cluster RCT | 12/ 60 | Primary care | IG 44; CG: 60 | IG: 40; CG: 59/ IG: 39; CG: 50 | IG: 63.6 (9.3); CG: 63.4 (9.1) | IG: 52%; CG: 55% | IG: 5.7; CG: 5.8 | No |
| Huisman 2009, Netherlands[20] | RCT | 6 | Secondary care | IG: 53; CG: 38 | IG: 21; CG: 12; CG+ manual: 7 | IG: 60.07 (6.76); CG: 56.69 (9.88); CG + manual: 56.74 (10.30) | IG: 52%; CG: 46%; CG + manual: 42% | IG: 7.3; CG: 7.2 | Unclear |
| Kattelmann 2009, USA[21] | RCT | 6 | Primary care | IG: 57; CG: 57 | IG: 51; CG: 53 | Unclear | Unclear | IG: 8.9; CG: 8.6 | No |
| Kronsbein 1988, Germany[22] | CCT | 12 | Primary care | IG: 50; CG: 49 | IG: 50; CG: 49 | IG: 65 (9); CG: 63 (8) | IG: 42%; CG: 39% | IG: 7.1; CG: 6.5 | Unclear |
| Lorig 2009, USA[23] | RCT | 12 | Primary care | IG: 186; CG: 159 | IG: 161; CG: 133 | IG: 67.7 (11.9); CG: 65.4 (11.4) | IG: 37.6%, CG: 33.8% | IG: 6.7; CG: 6.7 | Yes |
| Lozano 1999, Spain[24] | RCT | 24 | Primary care | IG: 120; CG: 123 | IG: 115; CG: 119 | IG: 63.8; CG: 64.7 | IG: 48%, CG: 48% | IG: 6.6; CG: 6.7 | Unclear |
| McKibbin 2006, USA[25] | RCT | 6 | Secondary care | IG: 32; CG: 32 | IG: 28; CG: 29 | IG: 53.1 (10.4); CG: 54.8 (8.2) | IG: 68%; CG: 62% | IG: 7.4; CG: 6.7 | Unclear |
| Miselli 2009, Italy[26] | RCT | 24 | Primary care | IG: 51; CG: 51 | IG: 51; CG: 51 | IG: 63.38 (9.68); CG: 63.70 (6.99) | IG: 45.1%; CG: 66.7% | IG: 8.7; CG: 8.8 | No |
| Mohamed 2013, Qatar[27] | RCT | 12 | Primary care | IG: 215; CG: 215 | IG: 109; CG: 181 | IG: 52 (8.9); CG: 55 (10.7) | IG: 37%; CG: 28% | IG: 8.7; CG: 8.6 | No |
| Muchiri 2015, South Africa[28] | RCT | 12 | Primary care | IG: 41; CG: 41 | IG: 38; CG: 38 | IG: 59.4 (6.9), CG: 58.2 (8.0) | IG: 12.2%; CG: 14.6% | IG: 10.8; CG: 11.4 | No |
| Penckofer 2012, USA[29] | RCT | 6 | Primary care | IG: 38, CG: 36 | IG: 26; CG: 34 | IG: 54.8 (8.8), CG: 54 (8.4) | IG: 0%; CG: 0% | IG: 7.8; CG: 7.9 | No |
| Pennings-Van der Eerden 1991, Netherlands[30] | RCT | 6 | Primary care | IG: 61; CG: 57 | IG: 43; CG: 40 | IG: 64.9 (9.77); CG: 63.86 (9.34) | IG: 39.3%; CG: 52.6% | IG: 8.0; CG: 7.7 | Yes |
| Philis-Tsimikas 2011, USA[31] | RCT | 10 | Primary care | IG: 104; CG: 103 | IG: 69; CG: 87 | IG: 52.2 (9.6); CG: 49.2 (11.8) | IG: 33.7%; CG: 25.2% | IG: 10.5; CG: 10.3 | Yes |
| Pieber 1995, Austria[32] | CCT | 6 | Primary care | IG: 45; CG: 49 | IG: 45; CG: 49 | IG: 63.9 (8.2); CG: 65.4 (11.2) | IG: 42%; CG: 47% | IG: 8.6; CG: 8.8 | Unclear |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rickheim 2002, USA[33] | RCT | 6 | Secondary care | IG: 87, CG: 83 | IG: 43; CG: 49 | IG: 51.6 (9.2); CG: 52.9 (12.8) | IG: 35.6%; CG: 32.5% | IG: 8.9; CG: 8.0 | Yes |
| Ridgeway 1999, USA[34] | RCT | 12 | Primary care | IG: 28; CG: 28 | IG: 18; CG: 20 | IG: 62; CG: 65 | IG: 33%; CG: 25% | IG: 12.3; CG: 12.3 | Unclear |
| Rosal 2005, USA[35] | RCT | 6 | Primary care | IG: 15; CG: 10 | IG: 14; CG: 9 | IG: 62.7 (8.1); CG: 62.4 (9.7) | IG: 20%; CG: 20% | IG: 7.7; CG: 9.3 | Yes |
| Rosal 2011, USA[36] | RCT | 12 | Primary care | IG: 124; CG: 128 | IG: 115; CG: 119 | IG: 45-54 (32.3%), 55-64 (29%); CG: 45-54 (27.3%), 55-64 (36.7%) | IG: 21.8%, CG: 25% | IG: 8.9; CG: 9.1 | Yes |
| Sarkadi 2004, Sweden[37] | RCT | 24 | Primary care | IG: 33; CG: 31 | IG: 33; CG: 31 | IG: 66.5 (10.7), CG: 66.4 (7.9) | Unclear | IG: 6.5; CG: 6.4 | Yes |
| Scain 2009, Brazil[38] | RCT | 12 | Tertiary care | IG: 52; CG: 52 | IG: 52; CG: 52; | IG: 59.3 (8.8); CG: 59.5 (10.2) | IG: 44.2%; CG: 50% | IG: 6.8; CG: 6.7 | Unclear |
| Smith 2011, UK[39] | Cluster RCT | 24 | Primary care | IG: 192; CG: 203 | IG: 166; CG: 171 | IG: 66.1 (11.11); CG: 63.2 (11.04) | IG: 54%; CG: 54% | IG: 7.2; CG: 7.2 | No |
| Sperl-Hillen 2011/ 2013, USA[40, 41] | RCT | 6.8/ 12.8 | Primary care | IG: 243; IE: 246; CG: 134 | IG: 239; CG: 130; IE: 239/ IG: 227; CG: 124; IE: 239 | IG: 61.2 (11.8); CG: 63.3 (11.5); IE: 61.6 (10.9) | IG: 49%; CG: 53.7%; IE: 50.4% | IG: 8.1; CG: 8.0 | Yes |
| Toobert, 2003, USA[42] | RCT | 6 | Primary care | IG: 163; CG: 116 | IG: 137; CG: 108 | IG: 61.1 (8); CG: 60.7 (7.8) | IG: 0%; CG: 0% | IG: 7.4; CG: 7.4 | No |
| Toobert 2011A& 2011B, USA[43, 44] | RCT | 12/ 24 | Primary care | IG: 142; CG: 138 | IG: 99; CG: 107/ IG: 97; CG: 93 | IG: 55.6 (9.7); CG: 58.7 (10.3) | IG: 0%; CG: 0% | IG: 8.4; CG: 8.2 | No |
| Torres Hde 2009, Brazil[45] | RCT | 6 | Secondary care | IG: 54; CG: 50 | IG: 31; CG: 26 | IG: 61.7 (10.5); CG: 59.4 (10.4); | IG: 24.1%; CG: 26% | IG: 9.3; CG: 9.3 | Unclear |
| Trento 2001/ 2002/ 2004, Italy[46-48] | RCT | 24/ 48/ 60 | Secondary care | IG: 56; CG: 56 | IG: 43; CG: 47/ IG: 45; CG: 45/ IG: 42; CG: 42 | IG: 63 (37-82); CG: 64 (45-80) | IG: 51%; CG: 64% | IG: 7.4; CG: 7.4 | No |
| Trento 2008, Italy[49] | RCT | 24 | Secondary care | IG: 25; CG: 24 | IG: 24; CG: 21 | IG: 64.6 (9.3); CG 68.1 (7.1) | IG: 52%; CG: 67% | IG: 7.8; CG: 7.8 | No |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Trento 2010, Italy[50] | RCT | 48 | Secondary care | IG: 421; CG: 394 | IG: 315; CG: 266 | IG: 69 (8.4); CG: 69.6 (8.4) | IG: 48%; CG: 54% | IG: 8; CG: 8 | No |
| Vadstrup 2011, Denmark[51] | RCT | 6 | Secondary care | IG: 70; CG: 73 | IG: 61; CG: 60 | IG: 58.5 (9), CG: 58 (10.3) | IG: 59%; CG: 60% | IG: 7.9; CG: 7.8 | Yes |
| Yoo 2007, Korea[52] | RCT | 18 | Secondary care | IG: 25; CG: 23 | IG: 25; CG: 23 | IG: 55.32 (7.56); CG: 55.08 (7.175) | IG: 32%; CG: 34.8% | IG: 8.3; CG: 8.7 | No |
| Zapotoczky 2001, Austria[53] | RCT | 12 | Secondary care | IG: 18; CG: 18 | IG: 18; CG: 18 | IG: 62 (8.2); CG: 53 (11.4) | IG: 44%; CG: 28% | IG: 8.6; CG: 8.0 | Unclear |

No.= number; RCT= Randomised controlled trial; CCT= Controlled clinical trial; IG= Intervention group; CG= Control group; IE= Individual intervention; SD= standard deviation; HbA1c= glycated haemoglobin

* A list of excluded studies is available on request from the first author.

***Supplemental Table S2: Intervention characteristics of included studies***

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Adolfsson 2007, Sweden[1] | 7 | Empowerment group education | Usual care | 5-8 | 12.5- 15 | 4-5 | No | Empowerment, motivation, learning principles | Yes (document and guidelines for facilitators) | Physicians, diabetes specialist nurses | Yes |
| Brown 2002, USA[2] | 12 | Group education program | Waiting list | 8 | 52 | 26 | Yes | Not stated | Yes (videos, lab results) | Bilingual Mexican American nurses, dietitians, community workers | Yes |
| Cade 2009, UK[3] | 1.75 | Expert Patient Program (EPP) (adapted for Type 2 diabetes) | Usual care | 12-16 | 14 | 7 | Yes | Not stated | Yes (written materials plus booklet) | Peer or lay led | Yes |
| Cheyette 2007, UK[4] | 4 | Weight No More program | Usual care | 8-10 | 12 | 8 | No | Not stated | Yes (visual teaching aids, food diaries) | Dietitian, physio, diabetes nurse specialist | Not stated |
| Clancy 2007, USA[5] | 12 | Group visits | Usual care | 14-17 | 24 | 12 | Yes | Not stated | No | Primary care internal medicine physicians, registered nurses | Yes |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cohen 2011, USA[6] | 6 | VA MEDIC-E (Veterans Affairs Multidisciplinary Education and Diabetes Intervention for Cardiac Risk Reduction-Extended) | Usual care | 4-6 | 15.5 | 9 | Yes | Not stated | Yes (cardiovascular report card, videos; Powerpoint slides; food log; Pedometers) | Pharmacist led, dietitian, nurse, physical therapist | Not stated |
| Dalmau Llorca 2003, Spain[7] | 12 | Group education | Individual education | 5 | 3 | 6 | Yes | Not stated | Yes (food photographs, written information; blackboards, transparencies and slides) | Medical resident, nurse | Not stated |
| Davies 2008[8]/ Khunti 2012, UK[9] | 1 day/ 2 half days | Structured group education program | Usual care | 8 (4 to 16) | 6 | 1 to 2 | Yes | Leventhal's common sense theory, dual process theory, social learning theory; Patient empowerment | Yes (patient resources) | Registered dietitians, practice nurses or nurse specialists | Yes |
| Deakin 2006, UK[10] | 1.5 | X-PERT program | Individual education | Average 16 | 12 | 6 | Yes | Patient empowerment, discovery learning | Yes (patient manual) | Diabetes research dietitian | Not stated |
| Delahanty 2015, USA[11] | 4.75 | Group lifestyle intervention (GLI) adapted 'Look Ahead' | Individual education | 8-10 | 28.5 | 19 | Not stated | Not stated | Yes (Look AHEAD group materials) | Dietitians | Yes |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domenech 1995, Argentina[12] | 1 | Group-based structured teaching/ treatment program | Usual care | 5-8 | 6-8 | 4 | Yes | Not stated | Yes (flip-charts, food photographs, question cards, individual log books, patient booklet) | Physicians | Yes |
| Edelman 2010, USA[13] | 12 | Group Medical Clinics | Usual care | 7-9 | 10.5-14 | 7 | Yes | Not stated | No | Primary care general internist, pharmacist, nurse or certified diabetes educator | Yes |
| Forjuoh 2014, USA[14] | 1.5 | Intervention: Group program (Stanford CDSMP) | Usual care (with written materials) | 7-17 | 15 | 6 | Yes | Not stated | Yes (companion book, audio relaxation tape) | Stanford-certified CDSMP lay leaders and master trainers | Yes |
| Gagliardino 2013, Argentina[15] | 6 | Patient education-Diabetes Structured Education Courses for Type 2 diabetes | Usual care (with written materials) | 6-10 | 7.5- 10 | 5 | Yes | Not stated | Yes (Illustrated materials, programme book, questionnaire cards, individual log-book, patient book) | Physicians | Yes (G4 only) |
| Gallotti 2003, Italy[16] | 36 | Group program | Usual care | 11 | 54 | 36 | No | Not stated | Yes (manual) | Medical doctors | Yes |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Heller 1988, UK[17] | 6 | Intervention: Group program | Usual care | 4-6 | 7.5 | 5 | Yes | Not stated | Yes (video tape, simple explanatory book) | Diabetes nurses, dietitian | Not stated |
| Hornsten 2005 & 2008, Sweden[18, 19] | 9 | Educational intervention (focus on personal understanding of their illness) | Usual care | 5-8 | 20 | 10 | No | Patient-directed, patient-centred, model of chronic illness | No | Diabetes nurses, nurse as moderator | Yes |
| Huisman 2009, Netherlands[20] | 6 | Self-regulation weight reduction intervention | Usual care, or usual care (with written materials) | 10-15 | 16 | 8 | Yes | Self-regulation principles, motivational interviewing | Yes (workbook, pedometer) | Health psychologist | Not stated |
| Kattelmann 2009, USA[21] | 6 | The Medicine Nutrition Wheel Nutrition Model education lessons | Usual care | 5-9 | 18-21 | 6 | Yes | Empowerment | Yes (Medicine Wheel Model for Native Nutrition, Powerpoint Presentations, individualized meal plan) | Registered dietitian, tribal member | Yes |
| Kronsbein 1988, Germany[22] | 1 | Group structured treatment and teaching program (DTTP) | Waiting list | 4-6 | 6-8 | 4 | Not stated | Not stated | Yes (flip-charts, food photographs, diabetes-related question cards, patients' log-books) | Physicians, physician assistants | Yes |
| Lorig 2009, USA[23] | 1.5 | Diabetes self-management program (DSMP) | Usual care | 10-15 | 15 | 6 | Yes | Not stated | Yes (book) | Peer leaders | Yes |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lozano 1999, Spain[24] | 24 | Health educational workshops | Usual care | 12-14 | 6 | 4 | Yes | Not stated | Yes (handouts, food photographs, self-care devices, insulin pen) | Nurses | No |
| McKibbin 2006, USA[25] | 6 | Diabetes Awareness and Rehabilitation Training (DART) | Usual care (with written materials) | 32 | 36 | 24 | Not stated | Social cognitive theory | Yes (handouts, educational materials, pedometers, mnemonic aids, printed materials) | Diabetes educators, dietitians | Not stated |
| Miselli 2009, Italy[26] | 24 | ROMEO | Usual care | 6-10 | 7 | 7 | No | Not stated | Not stated | Doctor, dietitian, nurse | Not stated |
| Mohamed 2013, Qatar[27] | 1 | Group-based intervention | Usual care (with written materials) | 10-20 | 12- 16 | 4 | Yes | Empowerment, health belief models | Yes (educational booklet for self-management, pictorial materials, questionnaires) | Physicians | Yes |
| Muchiri 2015, South Africa[28] | 9 | Structured nutrition education (NE) program | Usual care (with written materials) | 6-10 | 25- 29 | 14 | Yes | Social Cognitive Theory, Health Belief Model, Knowledge Attitude Behaviour model | Yes (education materials, diabetes education flip charts, hands on activities, demonstrations, food displays and vegetable gardening) | Sub-district dietitian, final-year nutrition and food science student, experienced dietitian, sub-district horticulture officer | Yes |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Penckofer 2012, USA[29] | 5.5 | Study of Women's Emotions and Evaluation of a Psycho educational (SWEEP) program | Usual care | 10-12 | 10 | 10 | No | Cognitive behavioural theory (CBT) | Yes (progressive muscle relaxation CD, video, workbook, log book) | Nurse | Yes |
| Pennings-Van der Eerden 1991, Netherlands[30] | 1.75 | Education program | Usual care | 8-10 | 21-28 | 7 | Yes | Not stated | Yes (written information, audio-visual aids, demonstration materials) | Physicians, dietitians, diabetologist, diabetes nurse | Not stated |
| Philis-Tsimikas 2011, USA[31] | 10 | Project Dulce diabetes self-management classes | Usual care | 6-12 | 32 | 16 | Yes | Not stated | Yes (handouts) | Lay community health workers | Yes |
| Pieber 1995, Austria[32] | 1 | Diabetes treatment and teaching program (DTTP) | Waiting list | 4-8 | 6-8 | 4 | No | Not stated | Yes | GP's, office staff | Yes |
| Rickheim 2002, USA[33] | 6 | Group intervention | Usual care | 4-8 | 7 | 4 | Yes | Adult learning model, public health nursing model, health belief model, transtheoretical model | Yes | Nurse, dietitian | Yes |
| Ridgeway 1999, USA[34] | 12 | Education/ behaviour modification | Usual care | 14 | 10.5 | 7 | Not stated | Not stated | Yes (teaching slides, handouts) | Registered nurse, registered dietitian, diabetes educators, physicians | Not stated |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rosal 2005, USA[35] | 2.5 | Group based intervention | Usual care | 15 | 25 to 30 | 10 | No | CBT, patient-centred counselling, social cognitive theory | Yes (log book, glucose meter, step counter, large visuals depicting traffic light system, dietary guidelines, soap opera drama) | Diabetes nurse, nutritionist, assistant | Yes |
| Rosal 2011, USA[36] | 11 | The Latinos en Control intervention | Usual care | Up to 15 | 30 | 20 | Yes | Social cognitive theory | Yes (log book, glucose meter, step counter, visuals of traffic light system, dietary guidelines, soap opera drama) | Nutritionist or health educator, assistant (trained lay individuals) | Yes |
| Sarkadi 2004, Sweden[37] | 12 | Experience-based group educational program | Waiting-list | 8-10 | 36 | 12 | Not stated | Not stated | Yes (video, game, booklet) | Pharmacists | Yes |
| Scain 2009, Brazil[38] | 1 | Structured group education program based on the Latin American Diabetes Association program for health care providers | Usual care | 8-10 | 8 | 4 | No | Not stated | Yes (brochure, log book, leaflet with anthropometric data and test results, recipes, cooking suggestions) | Nurse educator | No |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Smith 2011, UK[39] | 24 | Peer support meetings | Usual care | 10 | 9- 13.5 | 9 | No | Social support theory | Yes (educational resources; target card, video/ DVD, pedometer, laminated topic sheets) | Trained peer supporters | Yes |
| Sperl-Hillen 2011/ 2013, USA[40, 41] | 1 | Group education using the US Diabetes Conversation Map program: IDEA study | Usual care; and individual education | 8-10 | 8 | 4 | Yes | Patient-centred, non-didactic approach using the US Diabetes Conversation Map | Yes (Conversation Map support materials) | Certified diabetes educators (nurses, dietitians) | Yes |
| Toobert, 2003, USA [42] | 6 | Mediterranean Lifestyle Program (MLP) | Usual care | 5-10 | 116 | 6 | Not stated | Social Cognitive Theory, Goal Systems, Social Ecological Theory | Yes (program materials) | Registered dietitian, exercise physiologist, stress-management instructor, professional, lay support group leaders | Yes |
| Toobert 2011A & 2011B, USA[43, 44] | 12/ 24 | Viva Bien! Group education program | Usual care | 5-10 | 164/ 200 | 36/ 45 | Yes | Behaviour change theory | Yes (stress management CDs, recipes, pamphlets) | Physician, dietitian, exercise physiologist, yoga/ meditation instructor, support group leaders | Yes |

| Author, Year, Country | INT duration (mths) | INT | Control Group | No. per group | Contact time (hrs) | No. of sessions | Family/ friends included | Theory | Materials (type) | Facilitator/s | Training |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Torres Hde 2009, Brazil[45] | 3 | Group meetings | Individual intervention | Average 13 | 22 | 11 | Yes | Social learning theory, health belief model | Yes (educational pamphlets, videos) | Nurse-led, doctor, nutritionist, physio, OT | Yes |
| Trento 2001/ 2002/ 2004, Italy[46-48] | 24/ 48/ 60 | Structured education programme | Usual care | 9-10 | 8 / 15/ 19 | 8/ 15/ 19 | Yes | Systemic education approach | Yes (visual aids, food, graduated containers, flip chart) | Hospital physicians | Not stated |
| Trento 2008, Italy[49] | 24 | Group education sessions | Usual care | 8-9 | 4-6.5 hrs | 4-6 | Yes | Adult learning theory | Yes (operational manual, brochures) | Nurses, dietitian | Yes |
| Trento 2010, Italy[50] | 48 | Structured education programme | Usual care | 10 | 14 hours | 14 | Yes | Systemic education approach | Yes (as per Trento 2001) | Physicians | Yes |
| Vadstrup 2011, Denmark[51] | 6 | Group-based rehabilitation programme | Individual education | 8 | 17 hrs education | 9 | Not stated | Motivational interviewing; empowerment approach | Not stated | Nurse, physio, podiatrist, dietitian | Yes |
| Yoo 2007, Korea[52] | 13 | Comprehensive Lifestyle Modification Program (CLMP) | GBE then usual care | 5-8 | 25 hrs | 25 | Not stated | Self-efficacy | Not stated | Nurse researchers | Yes |
| Zapotoczky 2001, Austria[53] | 10 | Psycho educational group training | GBE then usual care | 18 | 15 hrs | 10 | Not stated | Learning theory | Not stated | Clinical dietitian | Yes |

INT= Intervention; Physio= physiotherapist; OT= occupational therapist; IDEA= Interactive Dialogue to Educate and Activate; US= United States; mths= months; hrs= hours; GBE= group-based education

***Supplemental Table S3: Risk of bias summary of studies included in systematic review****

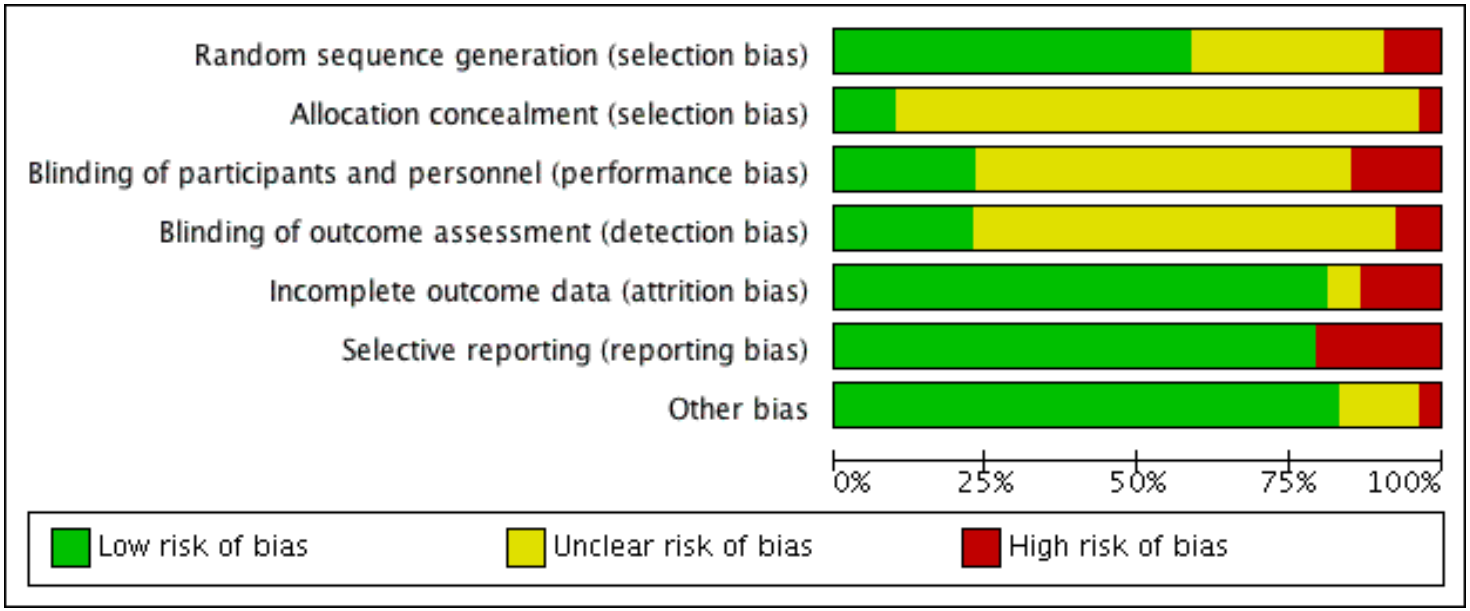
| Author, Year, Country | Overall Risk of Bias | Random Sequence Generation | Allocation Concealment | Blinding | Incomplete Outcome Data | Selection Outcome Reporting | Other potential sources of bias |
|---|---|---|---|---|---|---|---|
| Adolfsson 2007, Sweden[1] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Brown 2002, USA[2] | **Moderate** | Unclear | Unclear | Low | Low | Low | Low |
| Cade 2009, UK[3] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Cheyette 2007, UK[4] | **Moderate** | Unclear | Unclear | Unclear | High | Low | Low |
| Clancy 2007, USA[5] | **High** | Low | Unclear | Low | Low | High | Low |
| Cohen 2011, USA[6] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Dalmau Llorca 2003, Spain[7] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Davies 2008[8]/ Khunti 2012, UK[9] | **High** | Low | Unclear | Unclear | Low | High | Low |
| Deakin 2006, UK[10] | **Low** | Low | Low | Low | Low | Low | Low |
| Delahanty 2015, USA[11] | **Moderate** | Unclear | Unclear | High | Low | Low | Low |
| Domenech 1995, Argentina[12] | **High** | High | Unclear | Unclear | High | High | High |
| Edelman 2010, USA[13] | **Low** | Low | Low | Low | Low | Low | Low |
| Forjuoh 2014, USA[14] | **Moderate** | Unclear | Unclear | High | Unclear | High | Unclear |
| Gagliardino 2013, Argentina[15] | **Moderate** | Unclear | Unclear | High | Low | Low | Low |
| Gallotti 2003, Italy[16] | **High** | High | Unclear | Unclear | Unclear | High | Unclear |
| Heller 1988, UK[17] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Unclear |
| Hornsten 2005 & 2008, Sweden[18, 19] | **High** | Low | Unclear | Unclear | Low | High | Low |
| Huisman 2009, Netherlands[20] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Kattelmann 2009, USA[21] | **High** | Low | Unclear | High | High | High | Low |
| Kronsbein 1988, Germany[22] | **High** | High | Unclear | Unclear | Low | Low | Low |
| Lorig 2009, USA[23] | **Moderate** | Low | Unclear | Unclear | High | Low | High |
| Lozano 1999, Spain[24] | **High** | High | Unclear | Unclear | Low | Low | Unclear |
| McKibbin 2006, USA[25] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Miselli 2009, Italy[26] | **Moderate** | Unclear | Unclear | Unclear | Unclear | Low | Unclear |
| Mohamed 2013, Qatar[27] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Muchiri 2015, South Africa[28] | **Low** | Low | Low | Low | Low | Low | Low |
| Penckofer 2012, USA[29] | **Moderate** | Low | High | High | Low | Low | Low |
| Pennings-Van der Eerden 1991, Netherlands[30] | **High** | Unclear | Unclear | Unclear | High | High | Unclear |
| Philis-Tsimikas 2011, USA[31] | **Moderate** | Low | Unclear | Low | Low | Low | Low |
| Pieber 1995, Austria[32] | **High** | High | Unclear | Unclear | Low | Low | Low |
| Rickheim 2002, USA[33] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Ridgeway 1999, USA[34] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Rosal 2005, USA[35] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Rosal 2011, USA[36] | **High** | Low | Unclear | Low | High | Low | Low |
| Sarkadi 2004, Sweden[37] | **Moderate** | Low | Low | High | High | High | Unclear |
| Scain 2009, Brazil[38] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Smith 2011, UK[39] | **High** | Low | High | High | Low | Low | Low |
| Sperl-Hillen 2011/ 2013, USA[40, 41] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Toobert, 2003, USA[42] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |
| Toobert 2011A & 2011B, USA[43, 44] | **Low** | Low | Unclear | Low | Low | Low | Low |
| Torres Hde 2009, Brazil[45] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |

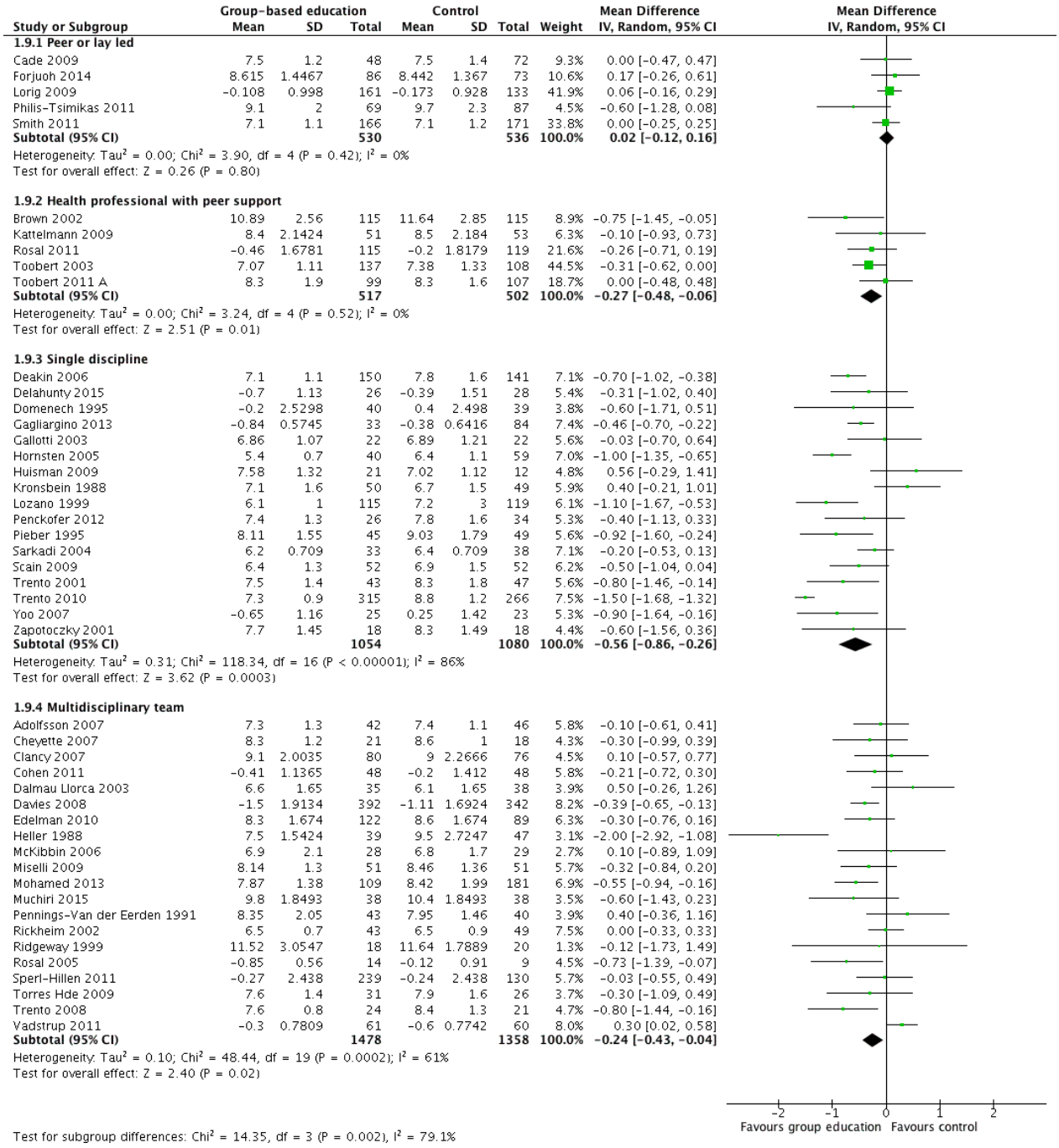
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Trento 2001/ 2002/ 2004, Italy[46-48] | **Moderate** | Low | Unclear | Low | Low | Low | Low |
| Trento 2008, Italy[49] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Trento 2010, Italy[50] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Vadstrup 2011, Denmark[51] | **Moderate** | Low | Low | High | Low | Low | Low |
| Yoo 2007, Korea[52] | **Moderate** | Low | Unclear | Unclear | Low | Low | Low |
| Zapotoczky 2001, Austria[53] | **Moderate** | Unclear | Unclear | Unclear | Low | Low | Low |

* Studies were ranked into three categories: a. all quality criteria met: low risk of bias; b. one of more of the quality criteria only partly met: moderate risk of bias; c. one or more criteria not met: high risk of bias.

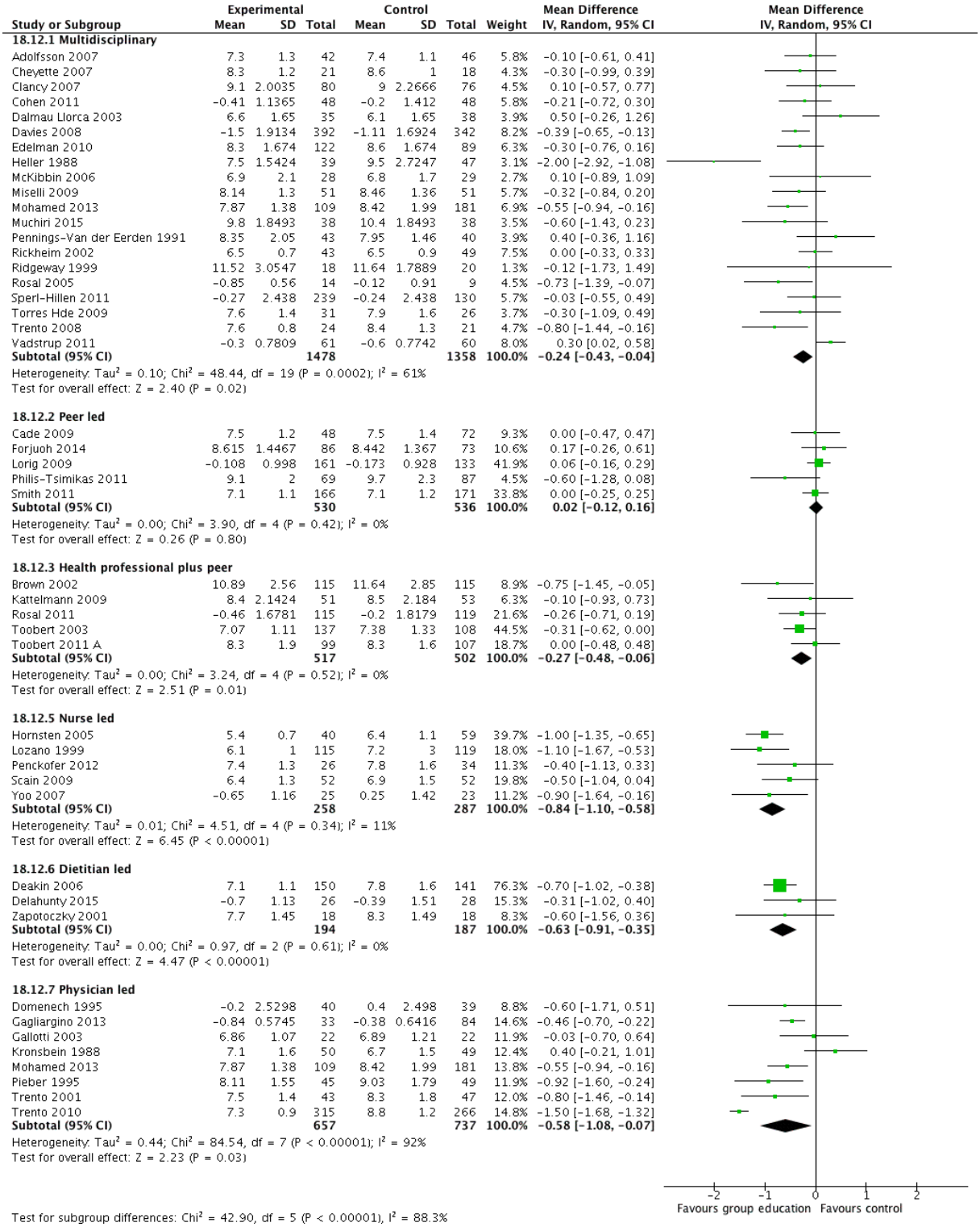
***Supplemental Figure S1: Overall Risk of bias for included studies***



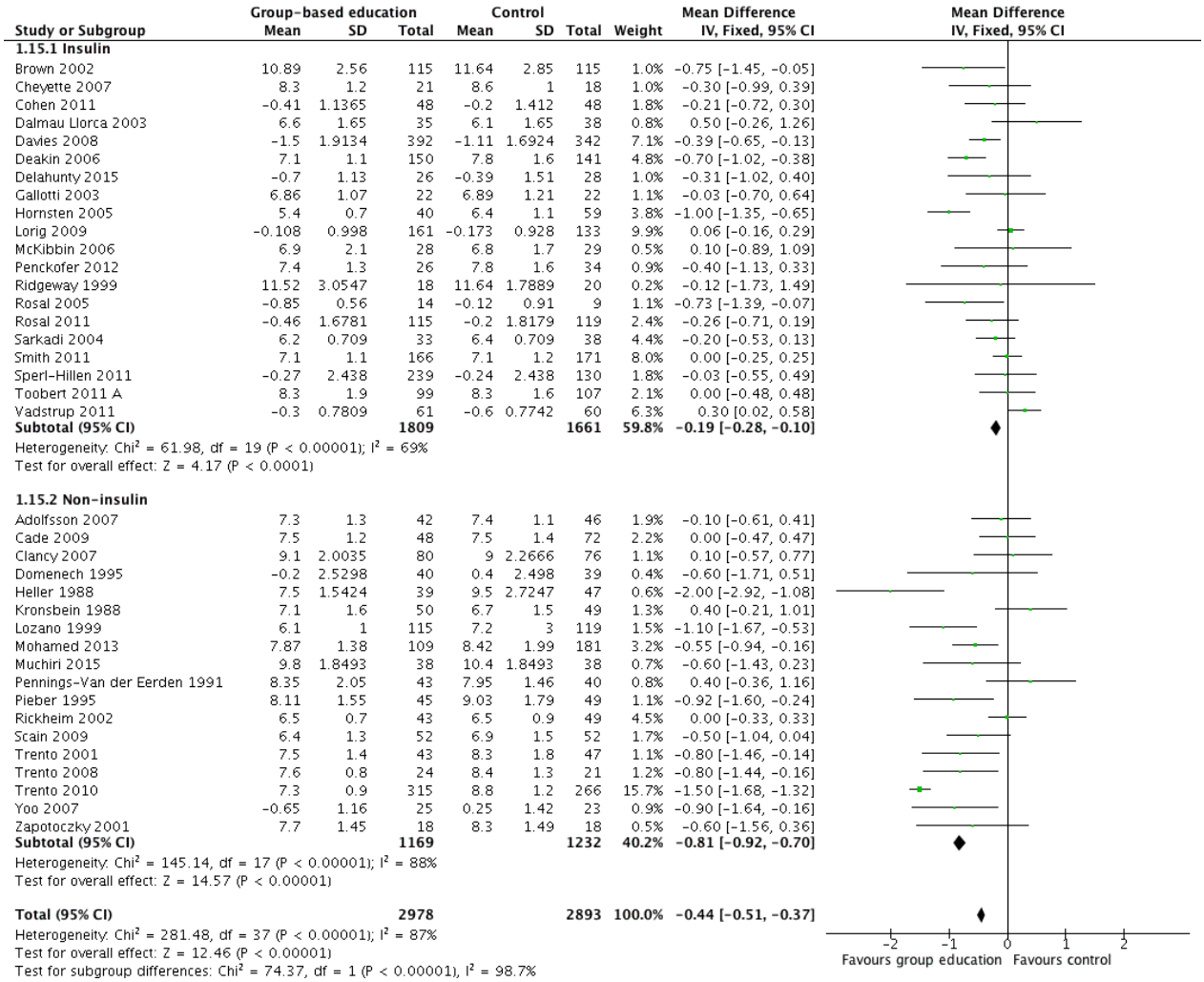
***Supplemental Figure S2: Forest plot- Subgroup analysis of group educators***



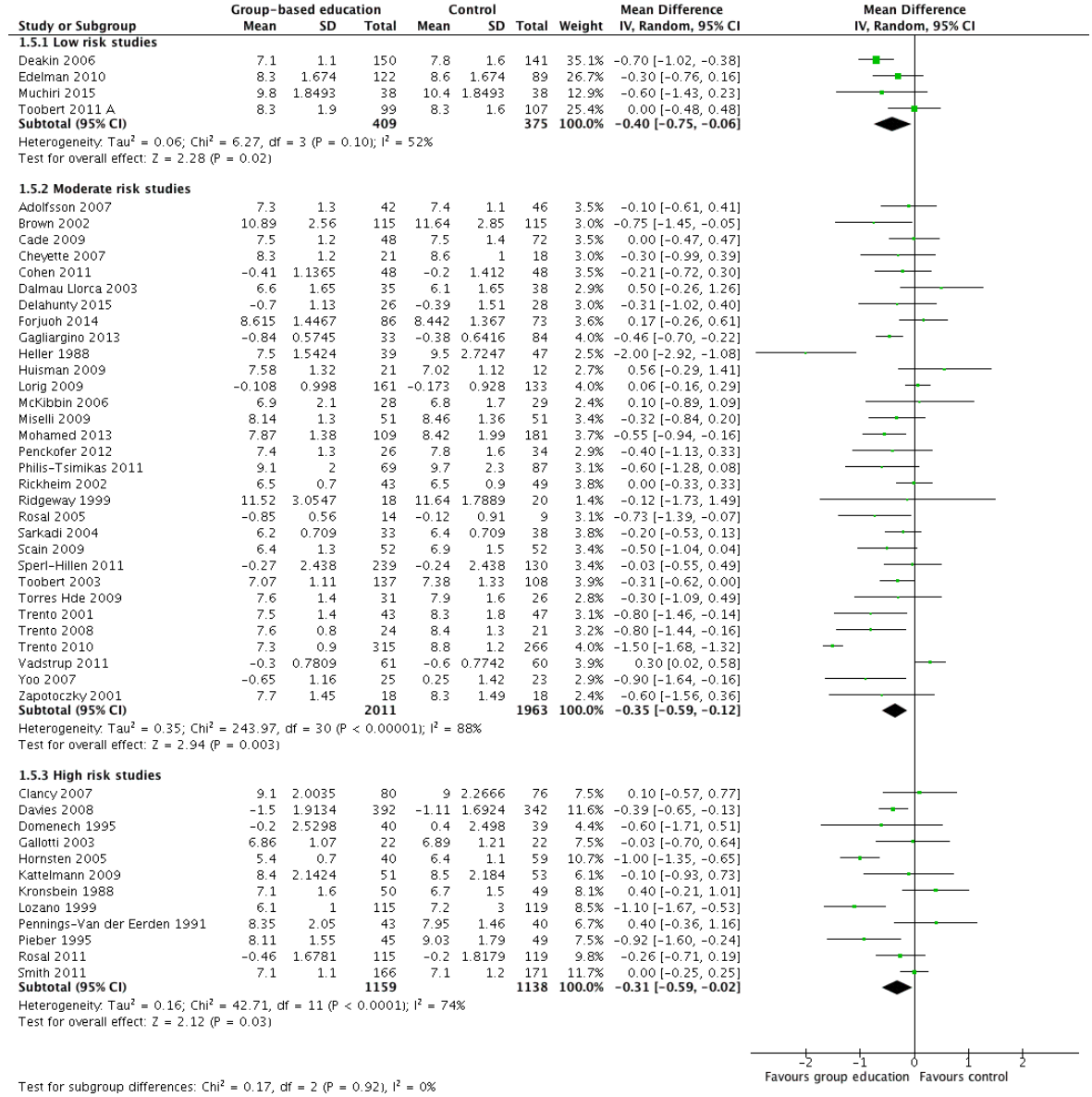
***Supplemental Figure S3: Forest plot- Subgroup analysis of group educators by individual discipline***



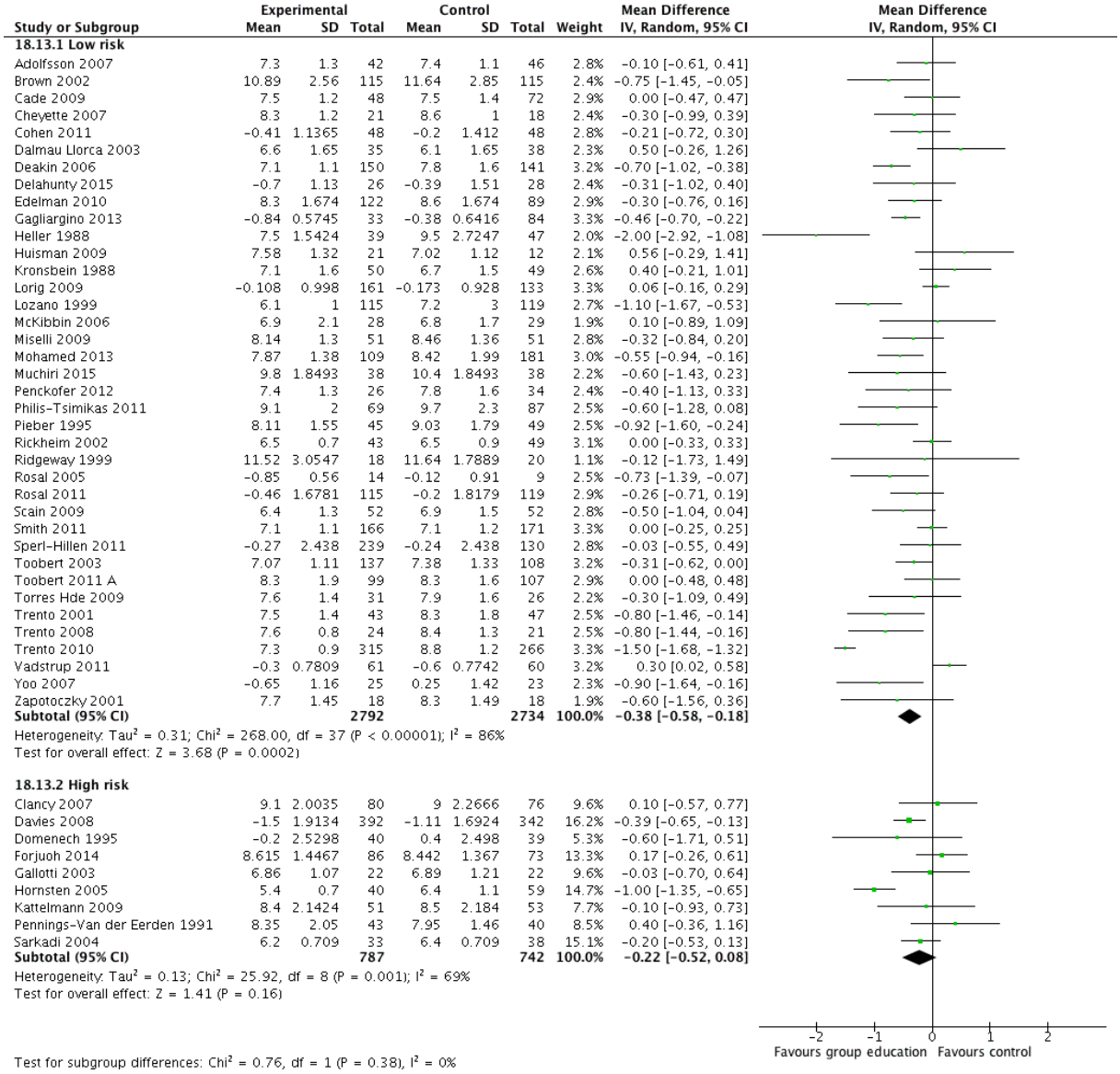
## *Supplemental Figure S4: Forest plot- Subgroup analysis of insulin therapy*



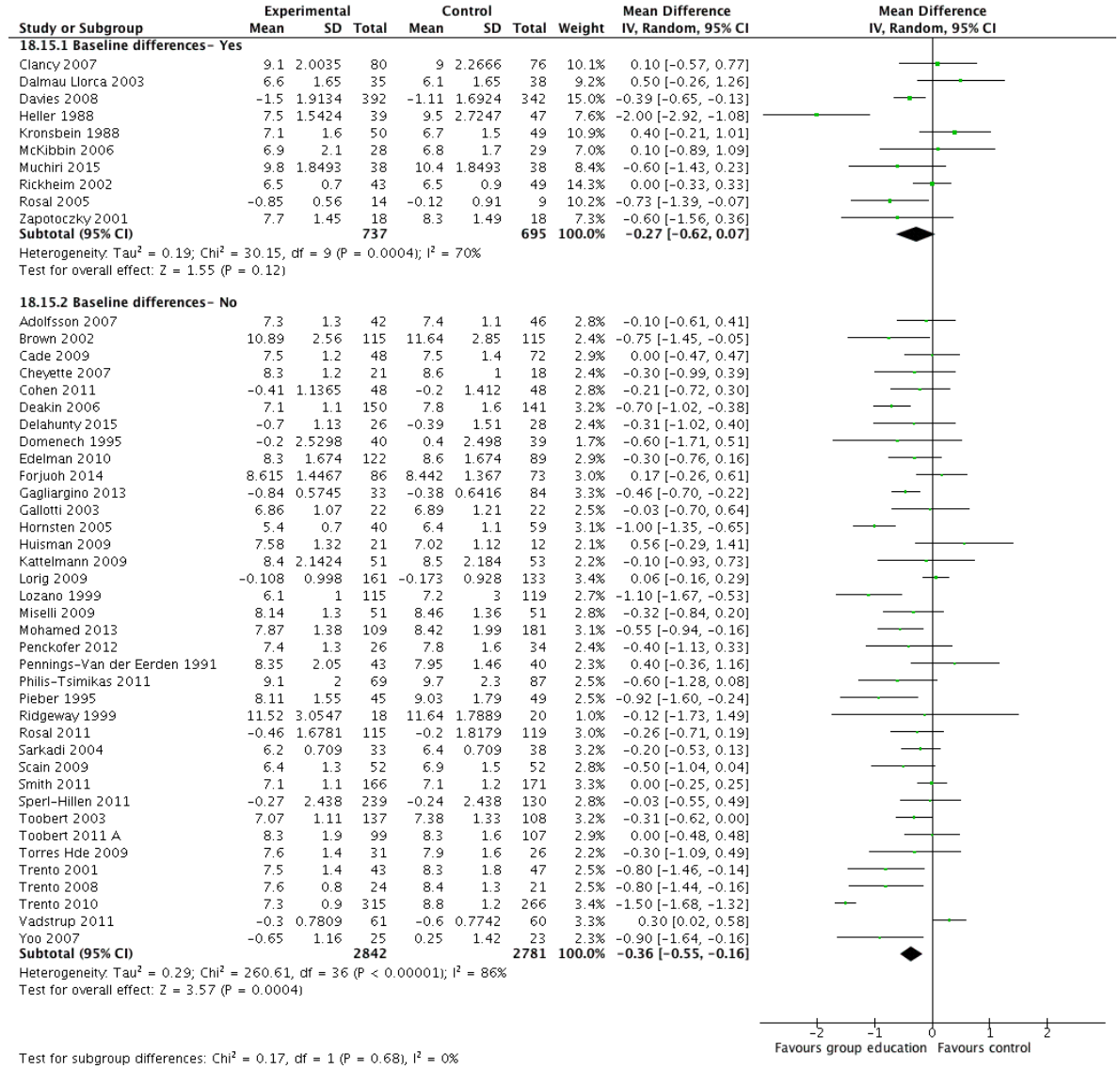
## *Supplemental Figure S5: Forest plot- Sensitivity analysis: overall risk of bias*



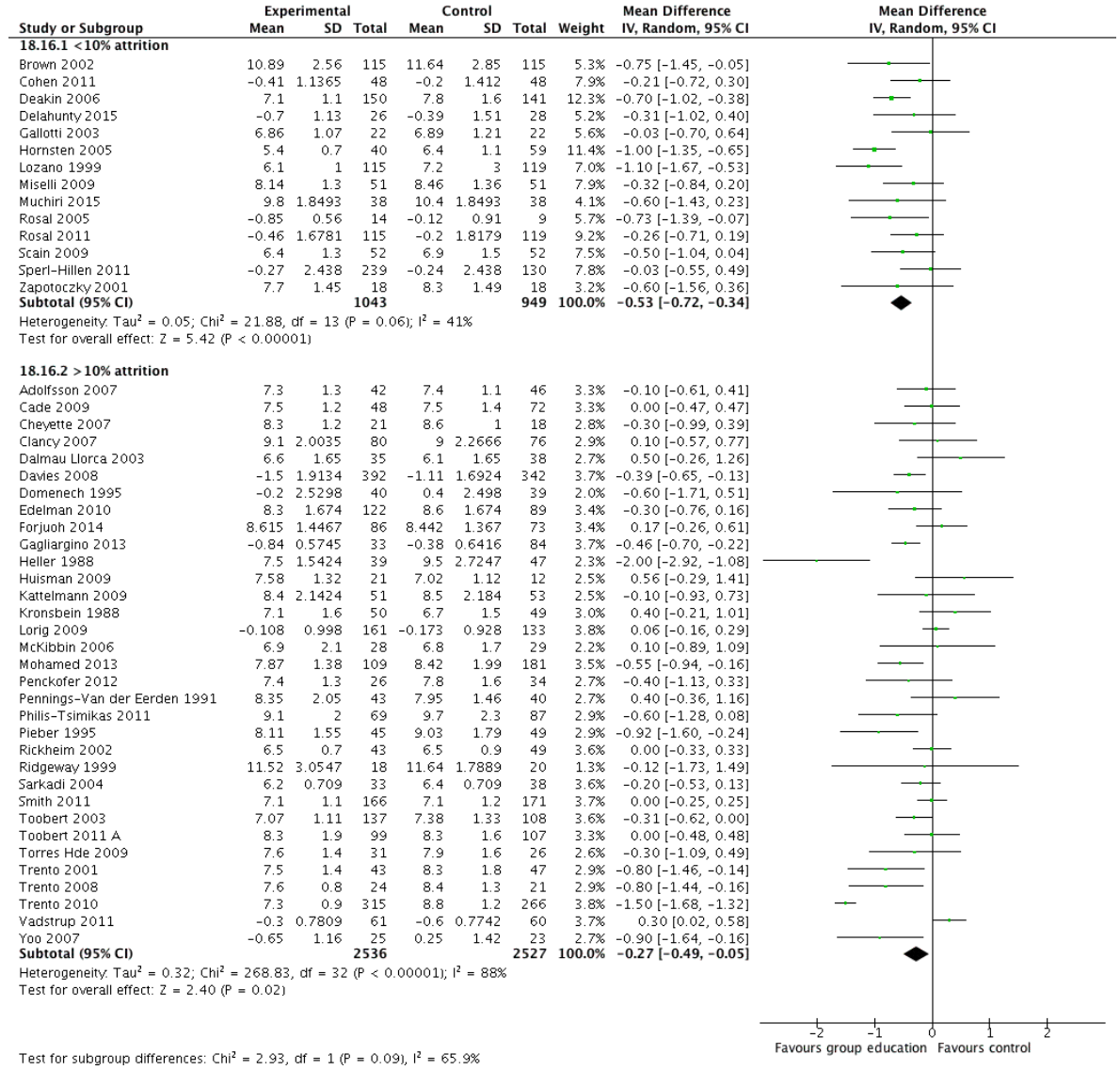
## *Supplemental Figure S6: Forest plot- Sensitivity analysis: reporting bias*



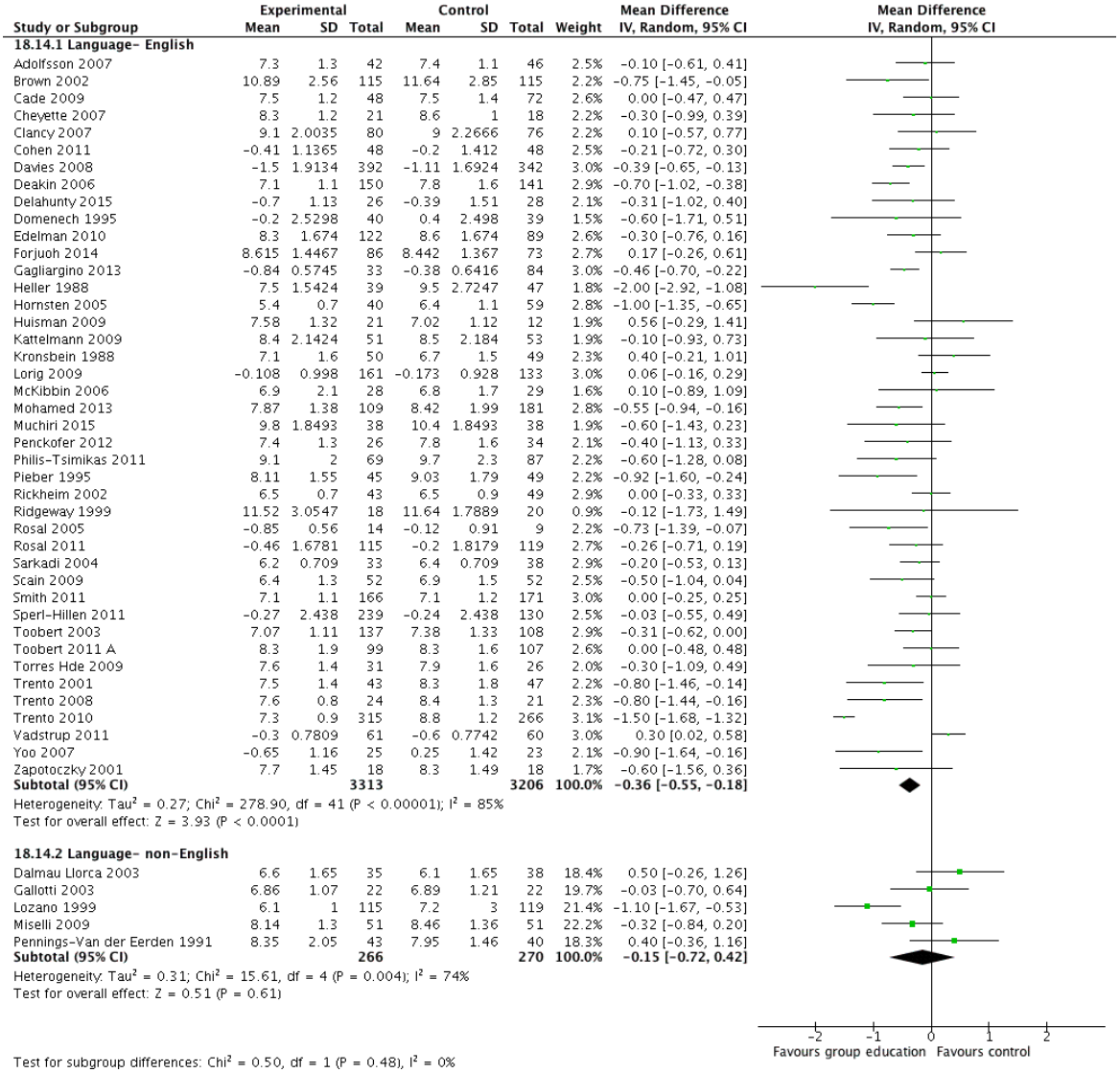
## *Supplemental Figure S7: Forest plot- Sensitivity analysis: baseline differences*



## *Supplemental Figure S8: Forest plot- Sensitivity analysis: attrition*



***Supplemental Figure S9: Forest plot- Sensitivity analysis: published in non-English journals***



***Supplemental Table S4: Summary of meta-analysis results of secondary outcomes assessed using standard mean difference at various time points***

| Outcome | Time point (mths) | N studies | N participants (IG/ CG) | Standard Mean Difference (95% CI) | P-value | Heterogeneity ($I^2$) | Heterogeneity (P-value) |
|---|---|---|---|---|---|---|---|
| QOL | 6-10 | 5 | 135/ 130 | -0.03 (-0.34, 0.29) | 0.86 | 34% | 0.19 |
| Depression | 6 | 3 | 201/ 176 | -0.62 (-0.93, -0.31) | 0.0001 | 28% | 0.25 |
| Energy intake | 6 | 5 | 182/ 203 | -0.11 (-0.44, 0.22) | 0.50 | 58% | 0.05 |
| | 12 | 4 | 389/ 406 | -0.21 (-0.58, 0.16) | 0.27 | 84% | 0.0003 |
| Physical activity | 6 | 7 | 619/ 478 | 0.23 (0.10, 0.36) | 0.0006 | 9% | 0.36 |
| | 12-14 | 3 | 486/ 376 | 0.21 (0.06, 0.35) | 0.005 | 11% | 0.33 |

N= number; IG= intervention group; CG= control group; CI= confidence interval; QOL= quality of life; mths= months.

***Supplemental Table S5: Meta-regression: association between study variables and primary outcome measure (HbA1c) (n=11)***

| Study variable | Univariate Analyses | | |
|---|---|---|---|
| | **Coefficient** | **95% CI** | **P-value** |
| **Theoretical model (RC: Yes)** | | | |
| No | -0.0240 | -0.43, 0.38 | 0.91 |
| **Type of educators (RC: Multidisciplinary team)** | | | |
| Nurse only | -0.4849 | -1.16, 0.19 | 0.15 |
| Dietitian only | -0.2418 | -1.10, 0.62 | 0.57 |
| Physician only | -0.1989 | -0.88, 0.48 | 0.56 |
| Psychologist only | 0.8659 | -0.66, 2.40 | 0.26 |
| Peer or lay led | 0.2516 | -0.40, 0.90 | 0.44 |
| HP led with peer support | -0.4977 | -1.17, 0.17 | 0.14 |
| Pharmacist only | 0.1059 | -1.18, 1.40 | 0.87 |
| **Training (RC: Yes)** | | | |
| No | 0.0428 | -0.42, 0.51 | 0.85 |
| **Materials (RC: Yes)** | | | |
| No | 0.0349 | -0.53, 0.60 | 0.90 |
| **Delivery setting (RC: Primary care)** | | | |
| Other setting | -0.1574 | -0.61, 0.30 | 0.49 |
| **Baseline HbA1c levels (RC: >7% in both groups)** | | | |
| <7% in both groups | 0.2164 | -0.29, 0.72 | 0.39 |
| **Intervention length (RC: <1 mth)** | | | |
| 1-3 mths | 0.1308 | -0.61, 0.87 | 0.72 |
| 4-6 mths | 0.1181 | -0.59, 0.82 | 0.74 |
| 7-12 mths | -0.1945 | -0.88, 0.49 | 0.57 |
| 13-60 mths | -0.3246 | -1.04, 0.39 | 0.37 |
| **Number of sessions (RC: < 5 sessions)** | | | |
| 6-10 sessions | 0.305 | -0.16, 0.77 | 0.20 |
| 11-20 sessions | 0.0122 | -0.58, 0.61 | 0.97 |
| > 21 sessions | -0.4054 | -1.13, 0.32 | 0.26 |
| **Number of participants (RC: 4-10)** | | | |
| 11-20 | 0.2290 | -0.20, 0.66 | 0.29 |
| **Contact time (RC: 8 or less hrs)** | | | |
| 9-12 hrs | 0.1286 | -0.53, 0.79 | 0.70 |
| 13-18 hrs | 0.2705 | -0.31, 0.85 | 0.35 |
| 19-30 hrs | 0.0715 | -0.55, 0.70 | 0.82 |
| 31 hrs or more | -0.1218 | -0.75, 0.51 | 0.70 |
| **Family and friends (RC: Yes)** | | | |
| No | 0.1436 | -0.27, 0.56 | 0.49 |

RC: reference category; CI= confidence interval; HbA1c= glycated haemoglobin; mths= months; hrs= hours

***Supplemental Item S2: References for Included Studies***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